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TIME AND MOTION STUDY AS AN AID TO PRODUCTION MANAGEMENT

Paper presented to the Institution, London Section, on 8th December, 1944, *by B. H. Dyson, M.I.P.E.*

In taking this opportunity of speaking to you on the subject of "Time and Motion Study as an Aid to Production Management" I do so for three main reasons.

(1) It is unquestionable that the future prosperity of this country, its industries and its people lies in our power to produce efficiently.

(2) Often a wrong attitude of mind towards the application of Time and Motion Study causes us to apply it to direct production operations only, instead of to aid total industrial efficiency.

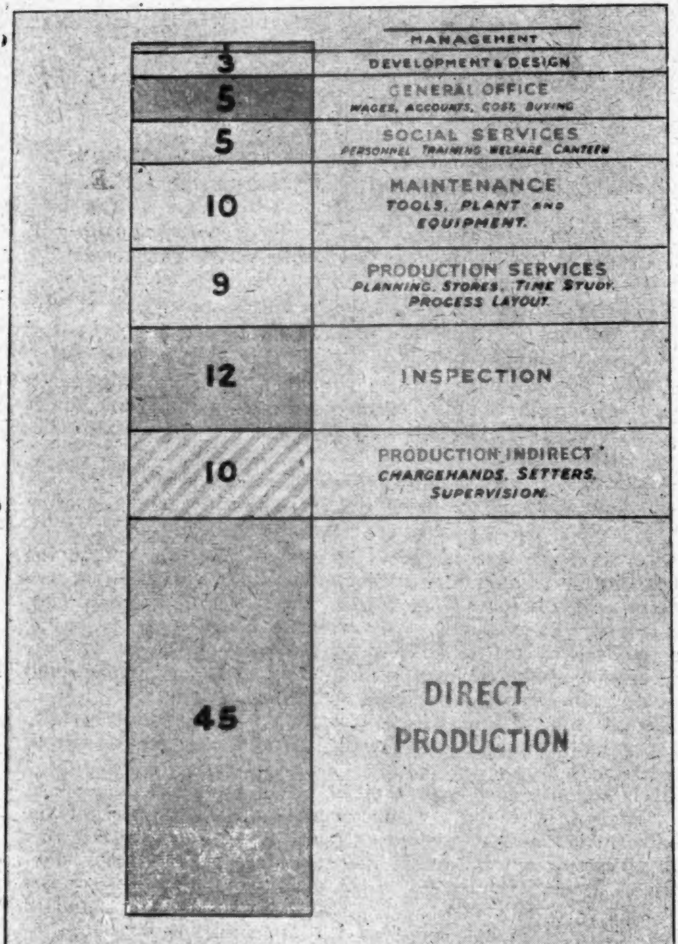
(3) I believe that production engineers should be able to appreciate and use Time and Motion Study as a measuring tool to assist in efficient management.

It is for these reasons that I have chosen to talk not on the mechanics or technique of setting time study standards, or setting up and training a Time Study or Motion Study Department, for there are, as you know, many good text books on these aspects; but I have chosen to put before you thoughts on the use of Time and Motion Study as one of the important tools that management can apply to assist in the efficient control of industry.

As this may be considered a somewhat unusual approach to the subject I would like to justify this by giving one or two of my reasons.

It is significant to note that in the Foreword to the recent Government paper on "Employment Policy" the gist of the statement is that "the success of the policy outlined in the paper will ultimately depend on the understanding" that a rising standard of industrial efficiency is the main plank that can support a "high level of employment, combined with a rising standard of living." It is not sufficient that unemployment should be cured—people must be productively, efficiently employed—employers must, by technical progress and productive efficiency, seek for greater output, rather than high prices, from which to reward labour and good management.

On the other hand, I read the following in a recent report of a visit to a well-known company. "On the question of asses-



COMPARISON of DIRECT & INDIRECT FUNCTIONS

Fig. 1.

sing the work done we were told that this is all based on the rate fixing department's assessments, most of which have been in existence for many years. This company admitted that the rates were very slack and that about double time was generally earned in spite of no real effort. Also that no shop time study was permitted as the men would stop work if a watch were brought out."

It will be appreciated, therefore, that one of the failures that has been flung at industry by those in high places, as well as those with their ears to the ground, from the House of Lords, the Commons, Trade Unions, articles in the daily press and technical publications is on the question of "Production Efficiency."

You will appreciate, I know, that production management is a complex build up of many functions, including Process Planning, Tool Design, Toolmaking, Inspection, Storekeeping, etc, etc. Often the people engaged in these and other non-producing departments represent 40% to 60% of the total Company personnel, and usually they are in the higher salary scale. Why then is so much attention given to the planning and measurement of work done by the direct production employees only ? Time and Motion Study could assist in providing the basis of measurement by which the efficiency of all the functions within the organisation can be measured. (See Fig. 1.)

One might ask, as possibly a good many of you have done, "Well, why has Time and Motion Study not been more widely accepted and used to its full extent."

I myself have always found that there is a background reason—often a very real and deep one moulded and built up by past experiences—for present difficulties. For instance, it is amazing to see how many people are afraid of a stop watch—its appearance will bring an expression of horror and disgust, a glance of forbiddence, a cold shudder of depression, or even resentment. Yet when the Plant Engineer brings out his photometer to measure the light intensity or his anemometer to measure air velocity, or even when the Inspector brings out his micrometer to measure the accuracy of the size of a piece of work, we get no resentment.

I therefore take courage in putting before you applications and future possibilities on :—(1) The Essential Functions of Time Study. (2) Time Study as a Basis for Financial Incentive. (3) Time Study as a Standard of Measurement. (4) Motion (movement) Study.

The Essential Functions of Time Study.

Unfortunately, both for Industry and the application of Time Study functions, too many managers have in the past looked on Time Study as a "cure all" for efficiency ; the unwary have thought that after one dose from the medicine bottle of the stop

watch their troubles would start to be cured—believe me it is often when the trouble begins.

Like all other methods of control, Time Study depends on, and can be no more efficient than the policy and honesty of purpose of the executive leaders who operate it. First the function must be defined, and should be "To be responsible for providing a standard of measurement for all functions—to apply these standards—to investigate and report on the results measured.

In order to carry out these essential duties it is important that the Time Study Department, embraces two things :—

(1) It must be built up on solid and knownn foundations.

(2) It must inspire unquestionable confidence from those who will measure by it and those who will be measured.

In order that it isbuilt on a known and solid foundation there must be a standard of impartial judgement—unbiassed—without any false or ulterior motive—without fear or favour. It must be upheld by Management and Company policy—not used just when convenient and cast aside at will.

The methods used in determining and applying the Standards must be unquestionable and open—above board and above all, consistent.

The personnel of the department should be correctly selected, have the right attitude of mind and be trained in analysing, investigating, seeking and obtaining facts, and provide a unit standard of measurement. The standard of measurement should only be applied as a financial incentive to direct workers when all other functions are efficient.

In order to inspire absolute confidence Time Study must provide a standard of measurement which everyone will respect in spite of all other inconsistencies—in fact its use may be to point to other inconsistencies.

It must be relied on by those who measure by it and those who are measured with it.

It must never be used to exploit and speed up direct labour.

Both management and workpeople must appreciate its limitations and advantages.

The method used must be understood by all and not cloaked in complication and mystery.

The personnel of the department must respect and make use of the assistance and knowledge of other departments and individuals.

Remember Time Study can never be a substitute for curing some other inefficiency—above all it is not and never can be a substitute for good supervision—but it can be effectively used by good supervision.

It would, of course, be ideal if a recognised National Standard of Procedure for investigating efficiency and a Unit of Quantitive Measurement were accepted. We have factory legislation and Factory Inspectors to lay down and investigate the standards of safety and internal conditions, Ministry Departments such as Ministry of Aircraft Production and Aeronautical Inspection Department to lay down and control the standard of quality to a specification, the British Standards Institution, who, with the aid of advice from both user and manufacturer, compile and issue standards of materials, components, methods, etc. Perhaps the nearest approach so far are the Ministry Technical Cost Officers whose function is to establish a standard manufacturing cost. Why not a National Standard for Time Study procedure and Quantitive Measurement? It would then be possible to interchange and compare industrial efficiency—it certainly is not at present.

Time Study as a Basis for Financial Incentive.

If installing a financial incentive scheme is contemplated it is important to ensure that the details I have listed under "essential functions of Time Study" are well and truly observed.

I do not intend to discuss the merits or demerits of the various bonus systems—it can be stated without giving offence that they all have their good and evil points, and the majority can be made to function effectively, but their success or failure depends entirely on their administration and the knowledge, experience and personality of those operating them.

It is most essential to get conditions of tooling, operation layouts, material control and supply, inspection standards, etc., organised and functioning correctly first.

By using Time Study as a basis for financial incentive the following should result :—

(1) Actual operating conditions and methods will be inspected.

(2) Standard method of doing a job will be determined and recorded.

(3) Individual operator and departmental efficiency can be checked.

(4) Shop supervision has a guide to the efficiency expected.

(5) Direct labour costs can be assessed.

(6) Operators are able to augment their wages according to their desire to increase output.

(7) Should add operator interest in the job and relieve the monotony (if this is desirable) on simple repetition jobs.

On the other hand you may, of course, have heard statements like the following referring to financial incentive :—

(a) From a workman : " There is something screwy about this bonus system, somewhere up in the office they get a lot of figures on a slip stick and come out with a figure that they put on my pay sheet. How do I know what I earn—I give it up."

(b) From a Foreman : " I have been told the rate is right but when I told the operator that he said he was ' doing his best but if the fellow that set the price had a specific method in mind he would like to know of it, or was it that there was no specific link up between what the rate-fixer thought could be done and what he actually had to do.' "

(c) A Works Manager reporting on a visit to another factory. " The bonus system varied depending on the different departments. In most of the machining and assembly departments an incentive bonus is paid based upon a guaranteed minimum. Most of the rates were admitted to be very loose and in some cases had been established 20 years ago, the result being that the average bonus was between 100% and 150%. In the forging shop men worked on straight piece work, that is they calculate their own price and quote to the management for producing something. Their average wages are £20 to £30 per week, and they come and go more or less as they like."

John Ruskin has said " If you examine into the history of rogues you will find they are as truly manufactured articles as anything else. We had better seek for a system which will develop honest men rather than for one which will deal cunningly with vagabonds." How truly this could be applied to time study systems.

It is therefore important to give full consideration to the reasons why some financial incentive schemes have failed ; they come under four main headings :—

(1) *Inconsistent results.* Due to intermixing of daywork and piecework—variable inspection standards—poor checking and coordinating procedure — individual job payment instead of daily total assessment payment or the rates set are not guaranteed.

(2) *Operators uncertain of their earnings.* Due to complicated bonus schemes—conditions not standardised—neglect in advising changes to the job or rate—no shop record of the conditions of the rates.

(3) *Jobs not defined.* Operation sequence and layout not planned—vagueness of operation to be performed—no method of recording and reproducing the conditions under which the job was time studied — insufficient instruction and training of operators.

(4) *Faulty rate fixing.* Due to absence of actual time study —set on exceptional or inexperienced operators—rates set on past performances or guesswork—inexperienced or unscrupulous rate fixers.

Knowing full well that I may be criticised and challenged I confidently state that these four reasons for failures can never all be wholly eliminated at any one time or on all jobs going through the factory, and therefore I venture to suggest that rates under most bonus schemes are inconsistent and uncomparable, and that earnings resulting from them often do not bear a real relationship to the skill and effort required to produce the job. If you do not believe this ask yourself about your own bonus system.

Are all conditions under which the work is performed well planned, standardised and controlled? This means you have selected the right person for each job, that supervision has mastered the problem of training people in a uniform method of doing the work, that materials are supplied in a uniform condition and at a constant flow without interruption, that inspection standards are constant, that there is uniform maintenance of machines, tools and equipment, that conditions of heating, lighting and other environment factors are at a constant level.

If you are satisfied that your system achieves all these—ask yourself " How do the bonus rates set in your company compare with the skill, responsibility, physical and mental application and working conditions required for the job?" Without this assurance the type of problems a financial incentive brings, are :—

(a) *Inequalities of earnings*—remember every employee judges the fairness of his treatment by comparing his rate with that of others, which he thinks are doing similar work—the bulk of grievances arise out of this comparison.

(b) *Inequalities of effort*—direct operators may have to work hard to reach a certain wage while on the other side of the bench viewers get away with easy work.

(c) *Restricted effort*—operators fearing investigation may systematically work slow, restricting their maximum effort and earnings to protect their easy job rates.

(d) *Preferential Treatment* — Foremen, Setters or Charge-hands, in order to keep the peace and line up inequalities, may have to sort out and share out the good and poor paying jobs.

(e) *Inflexibility of operators*—Where a change of job involves a loss of wages there will naturally be resentment to the change—and the new or urgent job is shelved for the good paying job.

For these reasons there are very many advantages in group incentive systems over individual rates, and an unbiased view contained in the report from a recent Medical Research review of absenteeeism in a modern factory should be of interest; it reads:—

"While any detailed study of incentives to work was outside the scope of this enquiry it must be pointed out that the results indicate clearly that payment by individual bonus gives rise to considerable dissatisfaction and seems to be associated with a tendency towards absence from work through sickness; the emotional disturbances caused by feeelings of insecurity, or supposed injustice may lead to loss of interest in work, fatigue and in some cases to direct illness. There is a tendency for women with nervous symptoms to be more liable to discontent if paid by individual bonus." The report goes on to state :—

"Dissatisfaction is markedly more frequent and also more intense among workers paid by the individual bonus method than amongst those paid by a group method. The effects of methods of payment on the attitude of the workers is especially marked in the sickness group, in which 75% of the women on individual bonus are worried or discontented, as compared with 35% of those on group methods. The greater number of discontented workers among those paid by individual bonus is statistically highly significant, both if the workers are considered as a whole and however they are sub-divided—the number is always at least twice that of workers on group bonus."

The experience of my Company has proved that there are a few points that need consideration before a group bonus scheme can be put into operation in order to ensure success.

(1) The selection of a good group leader.
(2) Groups should, wherever possible, consist of not more than 20 to 25 people.
(3) That within the group operators should not be tied to one operation—let them change around, they will soon choose the job they like best and therefore perform most efficiently.
(4) That in constituting a group, as far as possible it should be arranged that they produce completed jobs, i.e. completely machined components—complete sub-assemblies—or complete main assemblies.
(5) That the operators in the group should be able to see the total results of the work of the group.
(6) That the work produced by the group must be at a recognised stage where it is easy to control, by the checking system in operation, the quality and quantity of the work completed.

I personally have little or no use for blanket incentive bonus schemes—such as those that pay on the total output of the factory

unless it is a very small concern and those that pay a bonus to so-called indirect departments based on factory output. I believe it is well worth giving much more consideration to :—

(a) *Morale*. The desire of a worker to give of his best in quality and quantity is greatly influenced by his feelings towards his supervisors, his job and his company. Morale can seldom be bought by an incentive bonus.

(b) *Wages*. How do your wages compare with the skill necessary for the job, and also with the social requirements necessary to maintain a desirable standard of living.

(c) *Security*. A properly considered and administered policy of hourly rate, daily or preferably weekly wage rate promotes a greater sense of security and contains a better work incentive than most bonus schemes.

No incentive bonus scheme has been or ever will be a substitute for good management, also they can seldom if ever succeed in the absence of good management.

My personal belief is that in the future, when industry, its leaders and its personnel have advanced in attitude, outlook and production technique, that the hourly wage plus the incentive will be superseded by a weekly salary to all workpeople.

Time Study as a Standard of Measurement.

It is often not appreciated that time—seconds, minutes and hours—is a standard unit of measurement the world over. An hour in London is the same as an hour in Glasgow—an hour in England is the same as an hour in America, China, India—everywhere.

Remember money value is not standard—the rate per hour in

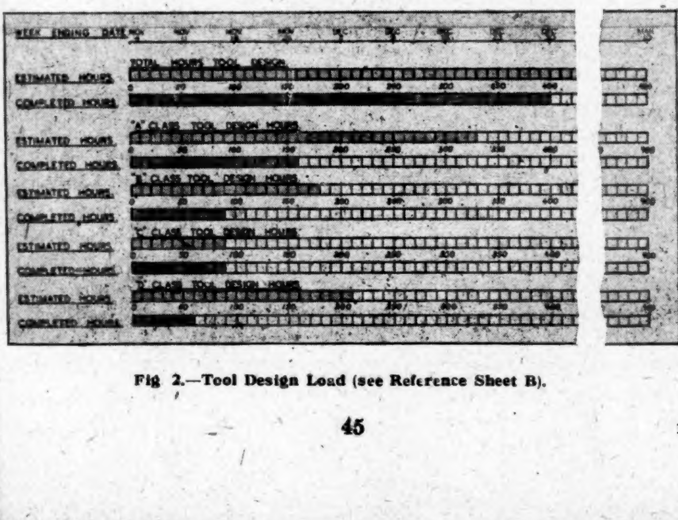


Fig 2.—Tool Design Load (see Reference Sheet B).

London differs from that in Glasgow. The pound in England became the dollar in America, the franc in France, etc. Even the weight standard of one ton varies between England and America, and changes to kilograms in Europe. The inches, feet and yards change to meters, centimetres, millimetres. These can all, of course, be converted—but the unit of time is standard.

Like myself you have probably tried to compare or reconcile manufacturing costs with other companies, and realising that when it comes to manufacturing operations it is almost hopeless.

I feel certain that practically all production engineers will agree with me that in the post war industrial world the production manager's main problem will be the control of production costs. Both control and costs must have as their basis the time unit——control of process planning, machine and labour loading, capacity and commitments, etc., must be built up on time—the fundamental that all costs are built upon is time.

I consider the application of Time Study as a standard of measurement can be considered to cover four main functions :—

(1) Calculating for production.
(2) Planning for production.
(3) Controlling manufacturing efficiency.
(4) Cost control.

TIME STUDY AS A STANDARD OF MEASUREMENT

The application of Time Study as a standard of measurement to aid production management can be considered to cover four main functions :—

Function	*Application*	*Measurement Required*
CALCULATING FOR PRODUCTION ..	Direct Production Labour ..	Type, grade and quanity of personnel.
	Direct Service Labour	do.
	Production Service Labour ..	do.
	Equipment Capacity	Machine and process classification.
		Machine commitments and capacity.
		Floor space.
PLANNING FOR PRODUCTION ..	Manufacturing Programme. ..	Process planning.
		Operation routing.
		Batch quantities.
	Production Control	Machine work loading.
		Labour work loading.
MANUFACTURING EFFICIENCY ..	Methods Inspection..	Tool and gauge efficiency.
		Heating and Lighting efficiency.
		Operation and motion efficiency.
		Safety efficiency.
		Machine and labour idle time.
		Service labour efficiency.
	Investigation	Inspection and control standards.
		Checking and recording standards.
		Job analysis.
COST CONTROL	Manufacturing and Factory costs	Direct labour standard costs.
		Production service costs.
		Deviations from standard and budgetted costs.

Reference Sheet A.

1. Calculating for Production.

Long before a delivery date can be given — a price quoted—a project undertaken or a production plan put into operation should come the function of calculating for production, under the headings of :—

(a) Direct Production Labour.

(b) Direct Service Labour.

(c) Production Service Department Labour

(d) Equipment Capacity.

The calculation of Direct Production Labour in order to assess the type, grade and quantity of personnel required for a specific project is almost a standard procedure.

But what about direct service labour—Inspectors, Chargehands, Setters, Labourers, Truckers ? What about Production Service Department labour—Tool Designers, Toolmakers, Planning Engineers, Draughtsmen, Storekeepers—yes, even Time Study men ? How do we know our commitments and capacity in these essential sections—or do we ?

TIME ALLOWANCES FOR PRODUCTION PLANNING LOAD

These average time assessments are used in calculating the work load commitments on the Operation Planning, Tool Design and Time Study Departments.

1. Operation Planning Classification.

(A) Major layouts involving numerous operations or new processes and new plant, e.g. Die castings or mouldings with several machining operations, difficult press work parts, multi-operation capstan work, major assemblies and sub-assemblies—**18 hours.**

(B) Average layouts, e.g. press parts with say, three normal operations, mouldings or castings with simple machining operations, auto parts with subsequent operations, straightforward capstan parts, simple assemblies—**6 hours.**

(C) Simple layouts e.g., most auto parts, mouldings and castings with no second operation, one or two operation press parts, etc.—**2 hours.**

2. Tool Design Classification.

(A) Major tools e.g., Dies and moulds with side cores, difficult press tools, large jigs and fixtures, etc.—**30 hours.**

(B) Average tools e.g., simple dies and moulds, straightforward press tools, jigs and fixtures, etc.—**10 hours.**

(C) Simple tools e.g., small cheap pierce and blank tools, most gauges, *simple* assembly jigs and handtools, etc.—**3 hours.**

3. Time Study Classification.

(A) Armature winding, field coil windings, bakelite moulding, die-casting, polishing, painting, Capstans (turning), complicated assemblies—**3 hours.**

(B) Drills (drilling, tapping, countersinking, etc.) presses, simple capstan operations—**2 hours.**

(C) Bakelite fettling, diecast fettling, simple asemblies—**1 hour.**

(D) Grinders—**45 minutes.**

(E) Automatics—**15 minutes.**

Reference Sheet B (see also Fig. 2).

I presume the majority of Production Managers do not just pile orders down to their Assembly Departments and then hope for the best—no, their Time Study standards tell them that either the assembly labour is sufficient to complete so many assemblies per week, or on the other hand that so many more operators are required.

Many companies now use machine loading to work load individual or groups of machines, and only issue the work required in the order and to the queantities that Time Study standards assess can be completed.

How many Production Managers have failed to meet the delivery date on a completed assembly, only to find on analysing the reason, that some of the components are not delivered to the assembly line in time because the tooling for some of the operations was not ready, because the tool designs were received too late, or because the design of a component was not finalised and issued early enough. The answer is that they did not know the commitments and capacity of their drawing offices, tool design sections, toolrooms, etc.

There is, as I see it, no reason why Time Study standards should not be used to calculate requirements in all activities, and I have included in the reference sheets one method of doing this.

2. Planning for Production.

It is important that the floor layout and working conditions are right first. Time Study standards should also be used in setting the manufacturing programme, ascertaining the economic batch quantities, and checking operation routing. It is amazing what inefficiencies an investigation of operation routing will reveal.

EXAMPLE.—A check recently exposed the fact that a certain component travelled to four factory floors and a distance of 4180 ft. Re-routing resulted in it travelling to two floors, and a distance of 1690 ft. (See Fig. 3.)

3. Manufacturing Efficiency.

Time Study as an aid to Manufacturing Efficiency can be one of the best inspections of the manufacturing methods being used. How efficient is the tooling and gauging that has been supplied, how efficient are the safety devices, how efficient is the machine tool maintenance ?

From Time Study investigations data, to illustrate the most efficient designs, can be compiled and recorded for use in the Tool Design Sections. When we order a jig, tool or fixture we are most anxious to know the price of the tool, when we receive it we check it for dimensional standards, but what about efficiency of

operating—one day we shall specify 'jig to be designed and made to facilitate a total handling time of so many seconds.'

Example A.—Press tool for sizing outside diameter of brass sleeve with standard type tool and press guard production of

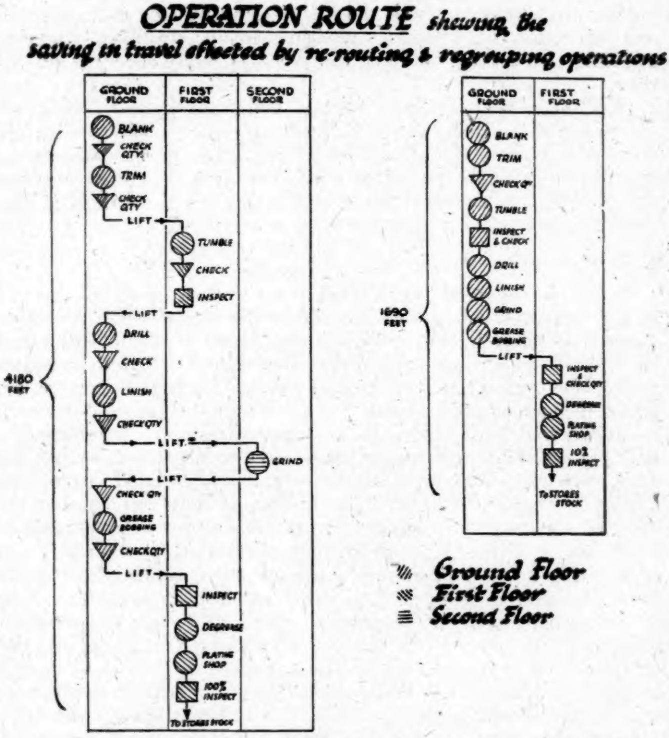


Fig. 3

610 per hour. With guard as part of tool accommodating channel loading of parts, production was 1090 per hour.

Example B.—On an originally designed drilling jig two hexagon headed clamp bolts were used, being tightened with a spanner, the total loading and unloading time being 92 seconds. After Time Study investigation the jig was modified, using tommy bar headed screws, reducing the total loading and unloading time to 35.5 seconds.

In investigating manufacturing efficiency the analysis of idle time may prove that the time booked to waiting material or waiting set-up would pay higher dividends if the functions of trucking were measured. The lost time in progressing a job through the factory is invariably caused not during the machining operations but in the time the job is lying waiting trucking from one operation to another, awaiting set-up, awaiting checking, awaiting inspection ; in fact the work is really clocking on idle time.

How often have I heard of time being taken in working out, discussing and arguing about an incentive scheme for setters when, if only that same time had been spent in the machining sections investigating where the setter wastes his time and then planning and laying out his work place and providing the right facilities, the true economics would have been achieved.

4. Cost Control.

I venture to suggest that a good many companies will not be able to get down to their pre-war manufacturing rates when their post war activities commence. While it may be due to the fact that they have made the fatal mistake of throwing their Time Study standard to the wind during the war period, it may be due to other reasons, too many inspectors for instance.

Inspection Example.—On a certain assembly line that was building electrical instruments the 4500 assemblies produced per week were being held up at the inspection stages, and also rejections due to breakages were high. Six inspectors were employed on the line and the average working time of each per week was found to be 67 hours. After Time Study investigation, including a review of handling methods, and improving the work benches and conditions, the number of inspectors was reduced to four, each working 50 hours per week. Rejections for breakages were considerably reduced by virtue of a free flow of work instead of buffer storage. In spite of a higher pay to the four inspectors a total saving on labour cost of £437 was achieved with a reduction in rejections of 4% on previous figures.

Remember production efficiency is not only ensuring that all plant, equipment and personnel are working all the time, it depends on how they are working and what results they achieve.

Motion (Movement) Study.

The belief that Motion Study means getting operators to assemble parts with both hands at the same time as operating a machine with their feet is a dangerous assumption. It has been well said, and there is more real truth in the statement than most people are willing to accept, that "Some day an intelli-

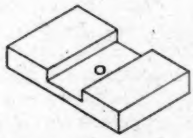
gent nation will awake to the fact that by scientifically studying the motions in its trades it will obtain the industrial supremacy of the world."

Now one thing this war has done is to dispel completely the idea that Britain is a land of muddlers, or that we are a decadent nation. Also in social activities we are level with most and in advance of many first class powers; the new Security plan in the latest Government white paper on Social Security Insurance, and also the recent announcement of the planned Demobilisation Scheme prove that we are determined to be in the lead. Now all planned schemes have to be backed by stability, and this war has driven home the fact that a first class power is not to be interpreted as one with monetary superiority, but one with productive superiority. I ask therefore—Firstly, "Are we going to be that intelligent nation which will not only study but put into practice the efficient motions in its trades and obtain the industrial supremacy of the world? Secondly, "Who better than Production Engineers—The Institution of Production Engineers — to champion and make effective this practical application?"

MOTION STUDY CHART.

PART NAME :- SLOTTED BAR.

DIAGRAM :-



OPERATIONS :- CUT TO LENGTH, MILL SLOT, DRILL HOLE.

1 UNLOAD BAR FROM VAN.
2 LOCATE TO STORES RACK.
3 ISSUE FROM STORES.
4 LOAD TO MILLING DEPT. RACK.
5 CUT TO LENGTH.
6 DEGREASE.
7 CHECK QUANTITY.
8 LOAD TO MILLING DEPT. RACK.
9 MILL SLOT.
10 CHECK QUANTITY.
11 FILE BURRS.
12 DEGREASE.
13 CHECK QUANTITY.
14 INSPECT.
15 LOAD TO DRILLING DEPT. RACK.
16 DRILL.
17 CHECK QUANTITY.
18 C'SINK & BURR HOLE.
19 DEGREASE & CLEAN.
20 CHECK QUANTITY.
21 INSPECT.
22 LOCATE TO STORES BIN.
23 SELECT FROM STORES BIN.
24 PACK FOR DESPATCH.

It is well known, although often forgotten, that in the engineering industry, particularly the larger organisations, that the number of direct producing personnel is invariably only 40% to 60% of the total. Why then is so much more " spot light " turned on the planning and measurement of work done by direct production personnel only ? Let us examine some of the reasons for this :—

It is often because our operations layouts deal with direct operations and floor to floor times only. I am a firm believer that the operation layout listing the manufacturing operations only is a sure sign of inefficiency ; it should list all operations, such as unloading the material in the Goods Receiving Department, trucking operations, cleaning, counting, inspection and storage operations—in fact door to door times. (See Fig. 4.)

Motion Study can be to the so-called indirect or service departments what Time Study is to direct production. In fact, in many instances Motion Study can be used where Time Study cannot be applied.

When we dwell on the fact that the work of the majority of individuals, whether they be typists, storekeepers, inspectors, toolmakers, etc., consists of up to 75% motions of the fingers, hands and arms, and to a large extent of lifting and shifting operations, then it is well to make these movements in the most efficient and least fatiguing manner.

When we remember that even in the majority of machining operations the time required to do the actual shaping or removal of material is on an average only 25% of the total time and that 75% is handling time, then motion study comes to really mean something.

Let us consider a few examples :—

(1) *Office or Paper Work.* You have possibly often said a lot of unprintable remarks about paper work—Government forms etc.—but how about our own industrial forms ? In the majority of firms, I think you will agree, there is too much paper work—but a lot can be done. We can simplify, combine, multiply or reduce copies, but don't expect that by just altering this form or that record that you will be freed ; look deeper for the reasons underlying the production of all this multiplicity of marks on paper, and find the fundamental remedies that will ensure the free flow of the activities that the paper work sets out to record. In other words, first do not strike at the paper work but at the causes for it. This is best done by listing down, as in Motion Study procedure, a process chart that records the movements and the work performed. Secondly, if the paper work is found necessary see that the form is laid out to suit the most efficient movements of the typewriter

carriage and standard line spacing. Two checks should be made to ensure the efficiency of necessary paper work :—

(a) Distance of travel to fulfil the function.

(b) Time involved to fulfil the function.

CHART OF PAPERWORK INVOLVED & ITS ROUTING AFTER RECEIPT OF CUSTOMERS ORDER

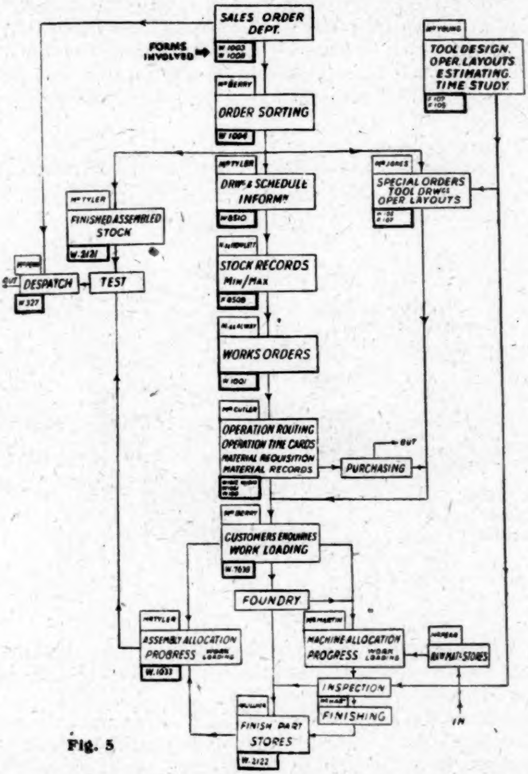


Fig. 5

With routine office work far too often the common practice of water tight departments and separate offices does not facilitate a work flow layout. There is no reason why individual clerks should not be so positioned that the work will flow in a logical sequence from one to the other, and to a time schedule. (Fig. 5.)

A definite routing and understanding of procedure and flow of information is best checked by a flow chart illustrating and explaining the movement of all the more important ducuments from department to department, and even from person to person.

How many typists are equipped with a frame to hold information to be typed in line with their natural sitting position and in line of vision. In fact, the re-designing of typists' desks similar to the Wurlitzer organ layout is worthy of attention. (See Fig. 6.)

(2) *Goods Receiving Departments.* I imagine if we asked the drivers of our suppliers vehicles what they thought of our receiving and unloading facilities their remarks would be unprintable, but we might deduct a good deal of information about the inefficiency of the

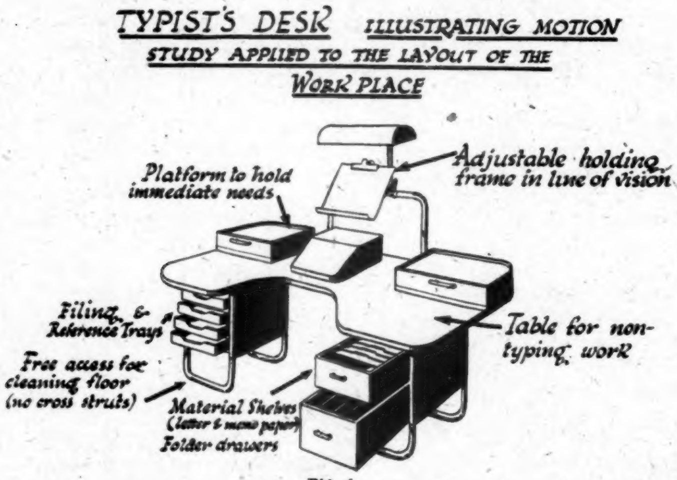


Fig. 6

facilities. There should be a logical flow of work from the unloading bank to the Stores—yet how often the Goods Receiving, Inspection and Stores Departments are completely separated, and sometimes not even positioned for work flow. Work flow benches, along which all incoming goods pass, should be arranged from the unloading bay to the Stores. Receiving clerks, Inspectors, Checkers and Stores Recording people should be seated by the side of these flow lines to progress the work to its destination. (See Fig. 7.)

(3) *Stores.* I wonder how many companies, considering themselves efficient, know how many selection of components from location bins in the Stores ready for issue, one storekeeper should average

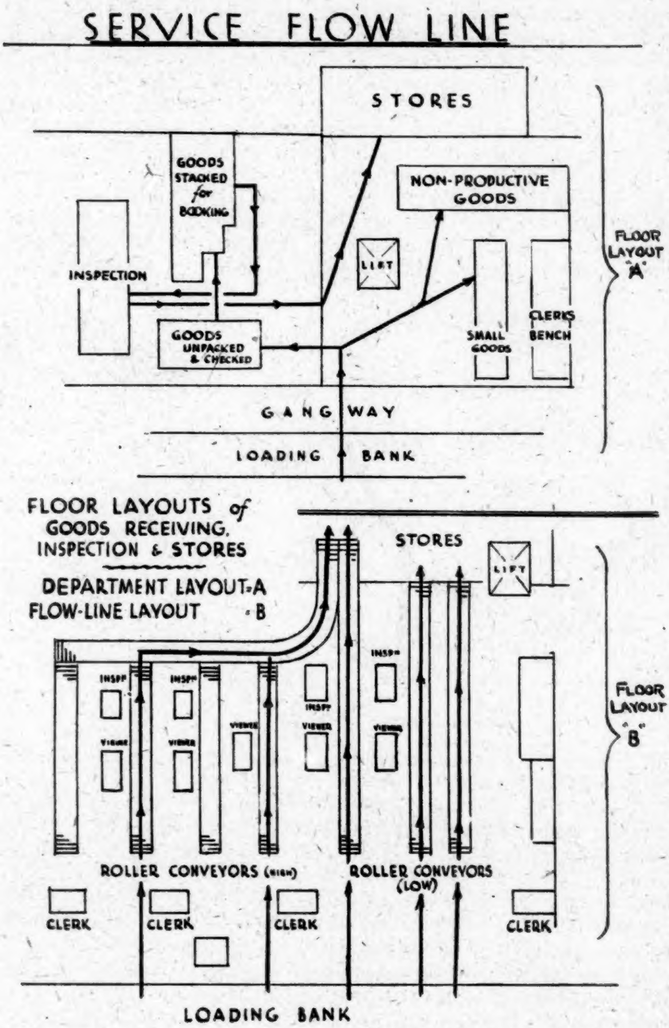

SERVICE FLOW LINE
STORES
GOODS STACKED for BOOKING
NON-PRODUCTIVE GOODS
LIFT
INSPECTION
GOODS UNPACKED & CHECKED
SMALL GOODS
CLERKS BENCH
FLOOR LAYOUT "A"
GANG WAY
LOADING BANK
FLOOR LAYOUTS of GOODS RECEIVING, INSPECTION & STORES
DEPARTMENT LAYOUT-A
FLOW-LINE LAYOUT - B
STORES
LIFT
FLOOR LAYOUT "B"
ROLLER CONVEYORS (HIGH)
ROLLER CONVEYORS (LOW)
CLERK
CLERK
CLERK
CLERK
LOADING BANK

Fig. 7

per hour over the week. Have you ever motion studied and committed to paper the movements a storekeeper goes through in selecting material for issue. How many Stores are laid out with the most frequently called for supplies located near the serving window. More important, how many investigations have been made of the necessity of serving from Stores windows at all—how many investigations into the loss through incorrect storage ?

In Despatch Departments the outgoing work could be flow lined passed checking clerks, packing, wrapping, cartoning, banding up and weighing, booking out and finally positioning in the appropriate location for transport, just like an assembly flow line. Receiving, Stores and Despatch work is 75% handling time,

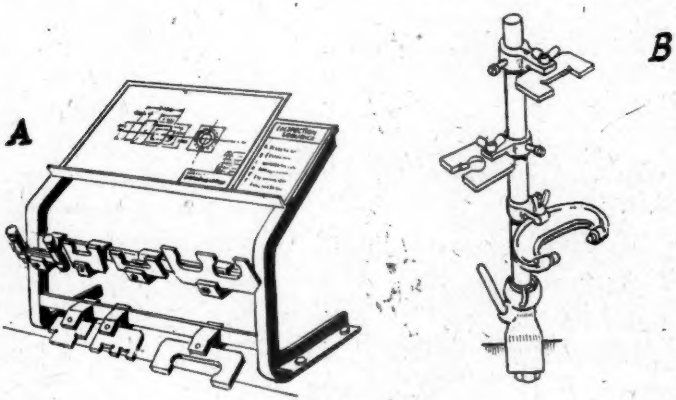


Fig. 8

and I have yet to see a handling job that Motion Study cannot improve by at least 20%.

(4) *Inspection*. Here again the work on repetitive viewing is 75% handling time. Apart from the normal consideration of correct bench heights, footrests, correct seating and lighting, how much more could be done. An adjustable frame should be provided to hold the drawing in line of vision, a frame to hold the Inspectior's operation layout telling him what to check, how to check and in what sequence to check. There should also be a fixed position to accommodate samples of the finish required—samples of both acceptable and rejectable conditions that are to be checked by vision. Instead of gauges being strewn all over the bench or one hand being used to hold the gauge, a Gauging Frame should be provided in which the various gauges can be placed in sequence of the gauging

operations. Many firms using the Gauging Frame method have achieved :—

(a) A saving of from 20% to 50% in inspection time.
(b) A separate workplace for each Inspector, overcoming their huddling together and gossiping.
(c) Increased life of gauges and less breakages.
(d) Motion Study establishment of the most efficient procedure.

Motor driven screw plug and ring gauges with the motor foot operated through a pre set friction clutch will considerably reduce inspection time and fatigue, and in fact results have proved a slight increase in the life of screw gauges.

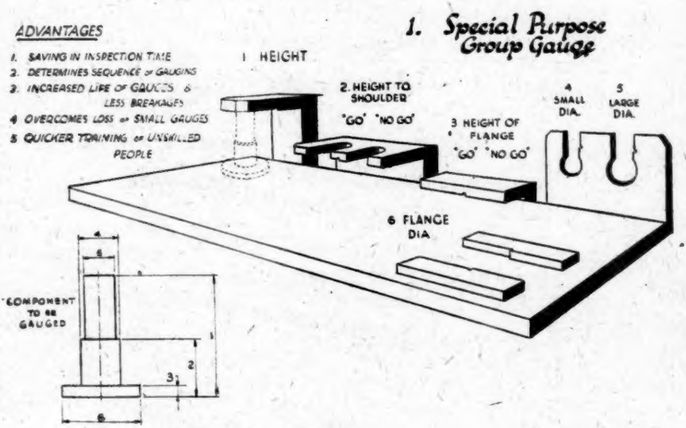


Fig. 9

Motion Study investigation can determine a fixed position for the batch of work to be inspected, for drop delivery of rejected parts to drawers that slide under the bench, and a fixed position for the container for inspected work. Far too many inspectors' work places are "just dumps" with few facilities and badly laid out, and yet this department is one of the vital functions in manufacturing procedure. (See Figs. 8 and 9.)

(5) *Toolroom*. How much of the skill of your toolmakers are you actually using, how much of his valuable time is engaged on skilled work ? Do your toolmakers have to do menial duties that a labourer could do—or better still that could be overcome ; such things as collecting drawings, standing at tool stores for emery paper, drills, waste, etc., or hunting for packing pieces, collars, bolts, clamps,

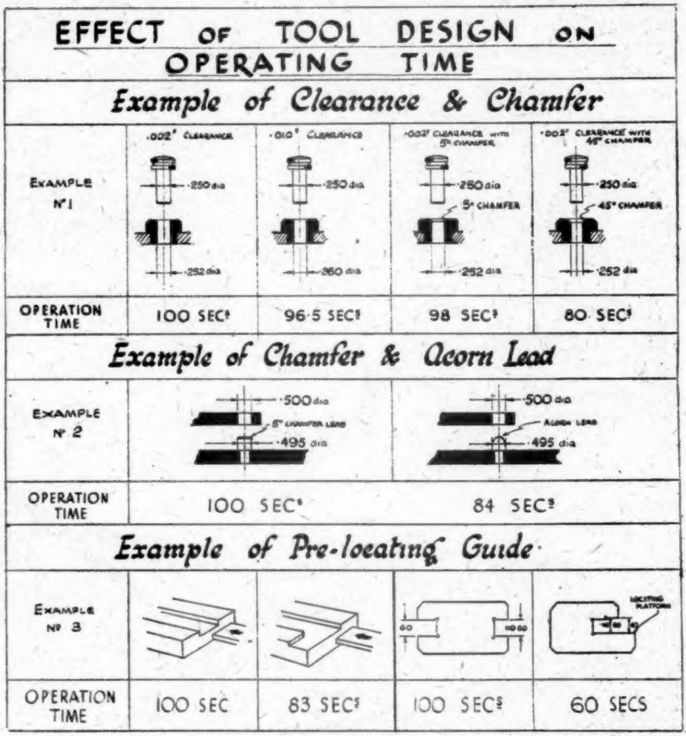


FIG. 10

spanners. Do they do labouring work, lifting and shifting of castings, steel blocks, vices, etc. How often have I seen two skilled tool turners labouring with a heavy 4-jaw chuck to lift it from the floor to the lathe head. I venture to suggest that there is almost a virgin field for movement study in the majority of Toolrooms.

(6) *Tool Design*. The designs of tools that violate the simple Motion Study basic principles are too numerous to mention, often because even the best of tool designers and tool makers do not appreciate motion economy.

How many appreciate that to locate a pin or spigot into a hole with .010 clearance takes 3.5% less time that locating to a hole

with .002 clearance, or that to locate a pin into the hole with .002 clearance with a 45° lead in bevel takes 18% less time than with a 10° bevel lead. (See Fig. 10.)

Positioning a part to a pin location jig with an acorn lead

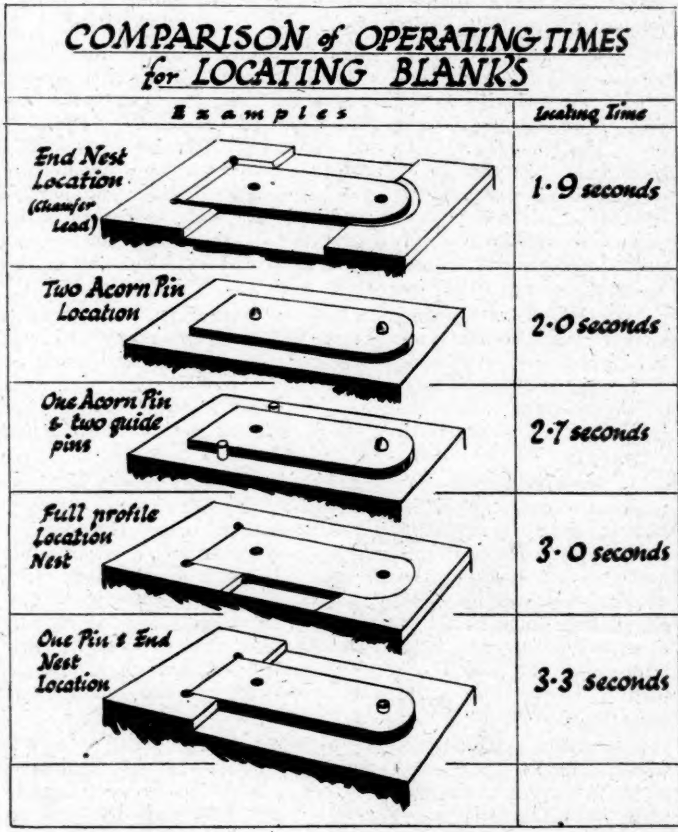


Fig. 11

takes 16% less time than with a locating pin with a 10° chamfer. Again, to locate a blank to a forming tool the time is as follows :—

(a) End nest location with chamfer lead—1.9 sec.
(b) Two acorn lead pin location—2.0 sec.

(c) One pin locating a hole and two guide pegs—2.7 sec.
(d) A full profile nest location plate—3.0 sec.
(e) One pin locating a hole and end nest location—3.3 sec.

How many Tool Drawing Offices have this information recorded and tabulated for the use of their draughtsmen and toolmakers ? (See Figs. 10 and 11).

On an assembly job the original fixture, designed to accommodate one assembly, embodied locating pins on which a coil was fitted, after which two sliding lock bars and two wing nuts were used to retain the coil in position during the assembly of contacts, etc. The time for loading and unloading with this jig was 11.5 seconds. After the job was Motion Studied a new fixture was developed accommodating two assemblies. The new fixture consists of slotted pillars into which the coils are dropped for support during the assembly operations, and the time for loading and unloading is now 1.75 seconds. The actual improvement on this assembly is from 20 per hour to 44 assemblies per hour.

Many people are inclined to look on Motion Study application as involving more elaborate fixtures and costly procedure, although in the majority of cases this is completely untrue, particularly so if thought is given to motion efficiency before the design or work of the toolmaker is completed. In fact, in most cases it has proved to be less costly than the haphazard method of error and correction.

(7) *Machine Design*. While considerable advancement has been made in recent years in the performance of machine tools, particularly in rigidity, accuracy and speed of removing metal, considerably less attention has been paid to the movements that must be made by the person operating the machine. Not only should the position of the operating controls obey the laws of motion economy, (such as eliminating unnecessary movements, shortening and simplifying necessary movements, balancing and synchronizing hand movements, minimising the travel of vision, etc.) but attention should be paid to the ancillary functions of setting up, and loading and unloading work.

How many machine tools are provided with an easily accessible frame to hold the necessary spanners, collars etc. ? What about a platform as part of the machine tool to hold the vise, chuck, faceplate, or is the shop floor considered the right place for such essential equipment ? How many machine tools are fitted with power or even hand operated mechanisms to load and unload work to the work head ? High speed modern machine tools remove metal at a rapid rate, but how many just finish there and do not provide means of breaking the chips and automatically removing the swarf and transferring it to a swarf disposal truck ? How

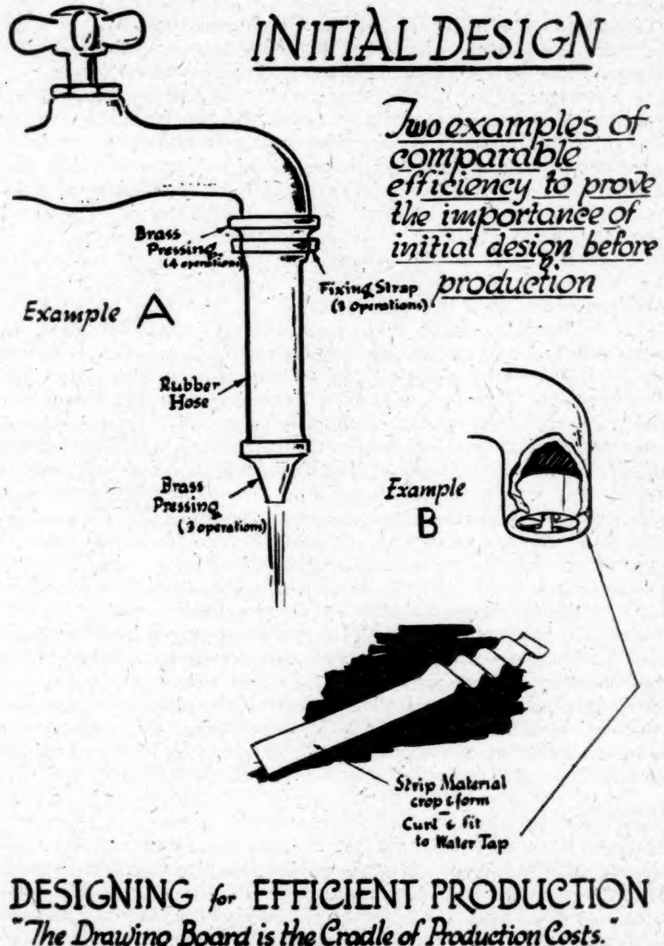


Fig. 12

about a seat for the operator, as part of the machine, that can be swung in or out of position as required ?

A well known American firm recently quoted an example of a threading machine for ball studs using a standard two spindle

threading head which cost £400 and produced 600 parts per hour. A machine was later designed to incorporate motion study principles; this cost £258 to build and produces 1,100 parts per hour.

(8) *Design*. My experience has taught me that the fundamental basis of all sound engineering economics has its foundation in the design of the product. In fact the drawing board is the cradle of production costs. I would venture to go so far as to state that unless the design of the product is efficient, both from a functioning and productive point of view, no matter how good all the other functions, time study, motion study or anything else, it will not be an economic proposition, and will in all probability be doomed to failure. Superiority in design will outclass all other aspects. (See Fig. 12.)

It is for this reason that motion study principles must be acknowledged and applied to the design of the product before it leaves the drawing board. You will appreciate, therefore, that I am not attacking designers when I say there is a great danger in the products of engineers becoming unnecessarily more elaborate. The design function has been calling increasingly on academic qualifications and designers are often looked on as mysterious beings well versed in the theory and arts of aerodynamics, and other equally high sounding arts whose requirements are unalterable laws, whereas so often they would welcome advice on practical production aspects. This is being done, with amazing results, in some companies by their Time and Motion Study engineers attending periodic meetings on design and development work.

Recently when my Company was contemplating manufacturing a new product, one of the preliminary procedures was to submit the various alternative designs to the Time and Motion Study Department for their comments. Their review of the alternative designs, together with the calculated production times to produce the component parts involved was used in arriving at the accepted design.

Conclusions.

If one were to experience 30% continuous idle time in a particular department the foreman responsible for that department would very soon be transferred or dismissed. If the 30% idle time was experienced in a factory as a whole it is pretty certain that under war conditions a Government Department would relieve the Manager of the responsibility of his job, or in peace time the Directors would dismiss the Production Manager. But this 30% idle time is actually happening in many departments and factories by the inefficient utilisation of skill, unnecessary lifting and shifting, and the non-acceptance of Time and Motion Study and the absence of a measuring stick of efficiency.

In conclusion I would draw attention to the report recently issued by the Joint Ministry Mission to the U.S.A. on American building economics, in which organised labour representatives are quoted as saying that "The fundamental reasons for the high efficiency in the American building trade can be traced to the different tempo existing and indeed expected of the whole industry. The different tempo is itself representative of and made possible by improved organisation." In other words, the results of Time and Motion Study used as an aid to Production Management.

Discussion

THE CHAIRMAN said it was usual to remark that the author of a paper needed no introduction, and no doubt many members of the Institution had heard Mr. Dyson discourse on the subject of time and motion study at various meetings, and would no doubt agree that he had the subject very well under control. Although not everyone would be in agreement with the principles or the objects of this branch of production engineering, he believed that the paper to be read that evening would be found to be of the greatest interest.

MR. LOGAN said that recently he had read a number of papers on time study, and only a few days ago he had read one on time study as an aid to production. The present paper was entitled "Time and Motion Study as an Aid to Production Management," and he wondered why it was that only recently motion study had been brought into the picture. Twelve or thirteen years ago he was trained as a time study engineer, but not as a time and motion study engineer, and one of the first things he was shown was not a watch or what the author called a "slip-stick," but several operations, demonstrating first how they should not be done and afterwards how they should be done, with improved handling methods. He wondered why it was that after such a lapse of time they were only just hearing about it again.

Secondly, there was the question of whether motion study could be separated from time study. His own view was that time and motion studies were inseparable and must be carried out by one man. The author suggested that time study methods must be known and understood by everyone. That was very difficult, because it might take several months to give a foreman the full facts, and a little knowledge was more dangerous than none.

MR. DYSON replied that the reason that time study came to be known before motion study was that in the first place time study was brought in to provide a financial incentive, and at one time that was thought to be its only use. To-day, however, the provision of a financial incentive was only a small part of it, and need not

enter into it at all.* Plate gauges were sometimes used instead of micrometers because progress had been made in manufacturing processes and it had been found that it was sometimes possible to use a simpler thing, and he suggested that motion study was fundamentally a simpler thing than time study.

There could be no hard and fast rule as to whether time study and motion study should be combined or separated. He would prefer them to be under one department and to have one head of a department which could be likened to a ladder with two sides, motion study and time study, leading up to what the department was to effect; but motion study could be used by people in the shop, by designers and by superivision just as well as by people within a specific department, just as with inspection. For example, it would be regarded with horror in some factories to give a foreman a stop-watch but not to give him a micrometer, yet they were both measuring tools.

When he said that it should be known by all, he was referring particularly to the bonus scheme. If there was a bonus scheme, it should be known and understood by all. Far too many schemes of that kind were so complicated that the majority of the people working under them did not know how to work out their bonus, and simply took the attitude that if there was anything to come they would be glad of it. He thought the system should be known by all. Above all, a time study scheme should not be looked upon as something which only the time study department could know. It was only human nature that what people did not know they suspected, but what they did know they trusted.

Mr. Blackshaw prefaced his remarks by saying that they would be of a controversial nature, and he wished to emphasise to the author that they were in the hope of promoting discussion which might possibly lead to his own conversion. He did not know how many handbooks had been published on time and motion study, but he imagined that the only people who got anything out of it were the publishers. In his view, time and motion were obviously synonymous terms, and he did not think that they could possibly be separated.

The author described time and motion study as a measuring tool. It would be interesting to know what form of measuring tool it was going to be when one had got it. Personally, he could not conceive it as a measuring tool at all, in the sense of being a finite measuring tool. He could conceive it being a guide, but that was very

* The treatises on motion study written by the Gilbetts were published betweed 1910 and 1920.

The author of this paper applied the principles of motion study in an American factory in 1926 and prepared booklets for use in his present factory in 1939 on this subject.

different from a measuring tool; one was specific and the other approximate. He suggested that the results of time and motion studies could only be approximate, because they had to take into consideration the greatest variable of all, the human element. It was not possible to define or to specify the human element. It was very important to bear that in mind. When people talked to him about 2.5 seconds, he regarded that as "all hooey," because human nature did not work like a machine.

The author referred to the fact that only a very small proportion of the labour involved in most production establishments was direct, and said "Why not apply time and motion study to the indirect labour?" How was it possible to arrive at a time and motion study of the man who was going to design the job? Personally, he had yet to meet a man who could think to order. One could think, but how long it was going to take to arrive at the desired result one did not know; it might take five minutes or it might take five years. Even coming to a more specific job, he did not think that it was possible to lay down a time for tooling a job, unless it was a repeat of something which had been done before. It might be possible to get some sort of guide, but that was all. He did not think the man was born who could say how long it would take to tool up a triple-expansion steam engine the first time it was done; yet the majority of engineering products were on that sort of scale rather than the scale of the manufacture of tooth-paste tubes, or something like that.

The author referred to a national standard of time and motion study. It would be interesting to know just what was envisaged there, because personally he could not envisage anything at all.

In some recently-published statistics with regard to production in this country, it was shown that some 60 or 70 % of the workers were employed in shops not having more than fifty employees. Time and motion study had very little application in the majority of those places, and in his opinion the only thing of value there was efficient supervision.

As a final word, and a purely personal one, while he appreciated that time and motion study had a certain place in the scheme of things he always felt that all the talk about it was in the nature of much ado about nothing. Far too much emphasis was placed on it. When the author referred to the scientific (he did not know where "scientific" came in) motion study and planning of the "routing" case which had been mentioned, his own reaction was, why did the man responsible route it wrongly in the first place? Why let one man do it and then set another man to alter it? One wanted men who could set the job out properly in the first place, not set it out anyhow and then send a crowd of people to see what they could do to put it right.

MR. DYSON remarked that it would obviously require another whole evening to convert Mr. Blackshaw. To take Mr. Blackshaw's last point first, what was wanted was not necessarily a time and motion study department but an attitude of mind on the part of the designer and the tool-maker and the supervisor which would lead them to appreciate motions and to appreciate times. He had emphasised in his paper the importance of knowing the limitations and the advantages. There were limitations to a micrometer, just as there were limitations to any other method of measurement.

On the question of whether time study and motion study should be separated, he agreed that if one wanted to make a time study the best thing to do was to see that the motions were right first, but one might not necessarily want to make a time study at all. If it was desired to find out, for instance, how much labouring work was being done by tool-makers there was no need to time-study it but there was need to observe the movements which they made. It all depended, therefore, on whether one wanted to apply a time standard or not. In the majority of cases movement studies could be used to observe the time wasted and it was not necessary to apply a time standard. On the other hand, if one set a time standard it was also necessary to look at the method used.

Mr. Blackshaw said "What are you going to measure, and what are you going to do with the result when you have got it?" Did Mr. Blackshaw send to his tool-room or to his machine-shop or to his stores an unlimited amount of work, and was he then satisfied if it was not done to time or if he received requests for more labour or found that half-a-dozen extra storekeepers had been employed? It was very much more probable that, with his wide experience, Mr. Blackshaw had an attitude of mind which enabled him to measure how much work a man should do, so that he used the method even if he did not call it time and motion study.

Personally, he agreed that it would never be possible to get a person to think to time, and that was why he said that in the design of product what was wanted was an attitude of mind on the part of the designer such that after he had spent hours and weeks and perhaps years on the job the production engineer had not to come along and ask him whether this or that limit was necessary, and whether it was really necessary to use a new part or whether an existing part could be employed. If the designer had motion-study principles at heart or could be given help in that direction, a great deal of time would be saved.

He would not say that it was possible in any tool design office to lay down a specific number of minutes and seconds for designing a tool, but if a customer asked for a job to be completed by a certain time one did not guess at the date—or did one? One must have some idea of the load that there was on the department, and

whether the time was measured in days and hours rather than minutes and seconds was neither here nor there ; time study would still be the standard for knowing the load. He would not be satisfied if his tool-room superintendent suddenly said to him that he wanted ten more tool-makers, but if he said that he had so many milling hours, so many turning hours and so many grinding hours, that so many hours of work under those categories had been issued to him in a certain period, that he had cleared so many and that his work load was therefore building up, that was an argument to which one would pay attention and on which one would act. Merely to stand nonplussed and say "I suppose you had better have another ten tool-makers " would be wrong, particuarly in view of the fact that for post-war exports it would be necessary to produce to time and to a price.

He referred to the need for a national standard because he found that so many companies started their time studies at a different stage. Some started merely with the operation of picking up the part and putting it in the jig ; others gave a time simply for doing the machining. Some included the setting up and some did not, and there were other variations. Before being able to compare time studies made within one's own company with those of others, it was necessary to find out a great many details as to where the study began and where it ended.

Mr. Barry, while largely supporting what the author had said, wished to challenge him on one point, being of opinion that motion study should be used far more in the direct production line than in the line the author had illustrated that evening. He felt that in the field of light engineering in particular the study of movement, which was the first essential in time study, made it possible to eradicate many of the difficulties which might otherwise arise afterwards. A great deal could be done by using motion simultaneously with time studies.

Mr. Dyson thoroughly agreed, and pointed out that in a diagram dealing with an assembly job he had shown the result of using motion study before time study. His point was, however, that in many cases it was not possible to use time study in such places as the tool-room and the drawing-office, but it was possible there to make use of movement study, if only in the form of giving information to the tool designer on the length of time that different motions actually took, not motion-studying the tool designer himself but giving him reference sheets, or getting him to make them out himself, of the time what different components and different methods would take. Whether one used time study in the factory or not and whether one used a financial incentive or not, one could still use movement studies.

Mr. Carnby said he supported Mr. Dyson rather than Mr.

Blackshaw, for to his mind, no matter what one called the system, investigation was bound to bring to light merits or demerits. If it brought to light demerits, then obviously the opportunity should be taken to correct inaccuracies or bad procedure. One could call the method time study, rate fixing or what one liked; if one plunged into a project without thinking about it there was bound to be difficulty, and any investigation of production methods, handling methods and time methods was bound to give a reward in increased efficiency.

There was only one point on which he did not altogether disagree with the author but thought that a distinction should be pointed out. The micrometer, after all, was only used to measure a man's work, but the clock was used to measure the dimensions of his prospective salary, and that was why the suspicion arose.

Mr. Dyson: Your last point assumes that the reason for time study is to apply a financial incentive—this is not necessary and much greater scope for time study is to provide a measurement for control.

Mr. Dyson added that if he had given a large number of examples that evening it was because they were true, and related to actual conditions in a factory which was probably of average efficiency. He could only assume that if they existed in that factory they must exist in others, although probably they were not known there.

The Chairman suggested there was a danger of the discussion becoming a "seesaw" between those who felt that there was something in the method and those who did not. There might be members present, he thought, who would like to ask Mr. Dyson specific questions on the subject rather than dwell on the advantages and disadvantages of the method.

Mr. Martin said the name "time study" was a dreadful bogey, but if one thought of it as being in the nature of Fire Brigade tactics—i.e., where everything was laid out in advance for a given job, and everybody knew who would run the nozzle out, who would deal with the hydrant and so on—one would understand what it really meant. It was a way of finding and standardizing the best way of doing something. That was how he understood time study, and that was how he thought that it was best appreciated, for 90% of it was just that.

Mr. Windmill referred to the use of time study as a basis for financial incentive, and said that in the summary of his paper the author asked why some incentive schemes had failed, and gave as the first reason "Intermixing of daywork and piecework." Personally, he heartily agreed that that would be a reason why an incentive scheme would fail, but he would like to hear the author's views on how in some businesses it was possible to get away from such a state of affairs. He had in mind a business where products

required in considerable numbers, and to which time study of the various parts and so on could be applied, were intermixed with what might be termed short-run jobs. In some cases that might be due to bad planning, or to bad policy on the part of the management in accepting short orders intermixed with long orders, but he would like to know what the author thought should be done where in the same shop there were long orders running which could be time studied and short orders where the order would be finished before the time-study man could get around to the machine.

Mr. Dyson replied that in many cases that difficulty could not be avoided. He had already stated that he did not know of any case in which all the reasons for the failure of an incentive scheme could be cured at one and the same time, and that was why he felt that incentive schemes could often do more harm than good. There was only one way in which he would attempt to deal with the problem, and that depended on the individual set-up of the factory concerned. Usually one wanted a different type of operator to deal with a small batch from the type who dealt with a long run, and often it would pay to have a setter-operator doing the short runs. It might pay to allocate one or two machines in the particular department to setter-operators for dealing with short runs, while the longer runs were handled by the rest of the department under an incentive scheme.

Mr. Betts asked how the author dealt with the training period of operatives when they went on to a new job, so far as their payment was concerned.

Mr. Dyson said the training period of operatives could be covered in several ways. It was possible, of course, to have a recognised training department or training period for the time that they were in a specific department, and a certain bonus could be paid, as fixed by management or company policy. On the other hand, if a rate was already established on the job and the operator was to be trained for it, an assessment could be made on the majority of repitition jobs at any rate of how long the operator should take to learn that specific job, and then there could be a step-in rate with an incentive for the operator to get on to the actual final rate.

Mr. Betts suggested that that must be a matter for discussion between the workpeople and the management, and Mr. Dyson agreed.

Mr. Burnett commented on the fact that the author had made no reference to the rating when making time studies, and said that though there were many questions he would like to ask he would limit himself to one : what experience had the author had of convincing operators that the time study engineer was capable of assessing the operator's ability ?

MR. DYSON said he had purposely not mentioned the technique of time study, because that would require a lecture to itself.

MR. BURNETT, amplifying his point, said he had had great difficulty on one occasion in convincing the stewards that it was possible to rate or to assess an average operator, and that was brought about because they claimed that it was impossible to find an average operator. Ultimately he discovered, after a good deal of cross-questioning, that the rate-fixing department up to that time were not rating the studies ; in other words, they were taking the net time and building up their piece work price from that, with the result that from the operators' point of view they were getting a set time irrespective of the efficiency of the operator on the job. That would obviously lead to confusion in the mind of the operator or setter with respect to an average operator.

MR. DYSON remarked that he had already referred to several of the drawbacks of using a financial incentive to direct operators, and he felt, he said, that far too often the matter had been tackled from that end rather than from the other. If they were to use motion study in tool designing and tool-rooms, stores, trucking and inspection they would gain the confidence of the direct operator, but as they applied it only to him and not to the others he said "Why pick on me ? " and he invariably did say that. It depended also, of course, on how open the timing and the method was, and to his mind it should be as open as possible. The operator should see the watch while the job was being studied, and one should talk to him at the time of the study and tell him about it. Too little attention paid at the time of the study to that sort of thing only resulted in long hours of discussion and wrangling afterwards, and afterwards was the wrong time to discuss the study ; the right time to discuss the study was when the study was actually being made. One should discuss it with the man who was doing the job, with the setter and with the foreman on the job while the study was taking place.

If the time study engineer set himself up on a pedestal and took the attitude that he had a method or technique which nobody else could understand, and if he let that attitude be obvious when he went into the shop and took a study and went away, and a few hours or days afterwards sent down to the man or to the foreman a rate on the job, he was asking for trouble. On the other hand, if he was open about it and discussed the job with the man before the study began and passed the comments that he wanted to make on the speed and the method of doing the job before the study started, and then, if he was not satisfied while the study was going on, said so the man would have confidence in the study and in the figures which had been taken and recorded, and it would be possible to break down the resentment which the other method aroused. That

would not, however, be done in five minutes, because if one gave a dog a bad name it would stick. People with little knowledge of time study had thought that once they got this medicine bottle and issued a dose it would cure the trouble, but they had caused the trouble. That was why he was very much in favour of spending much less time on studying the direct operator and tying him down to seconds, and much more time on the design of the fixtures and so on so as to save not seconds but minutes.

MR. BALDWIN asked whether the author thought it was practical to apply time study in a department such as a plating department, and, if not, whether he could suggest any incentive to offer in such a department.

MR. DYSON said it was possible to apply time study to a plating department, but it meant that instead of the instructions on the process layout simply calling for cadmium plating they must list in detail the procedure which was gone through—the washing the cleaning, the drying and the rest of it—and that must be studied. That could be done. In some plating shops the racking of components or the wiring up of components was studied separately from the cleaning and the cleaning separately from the actual plating, but whether it was desirable to go to that length depended on the flow of work going through the department.

On the other hand, there could be a group scheme, into which all and sundry were brought, but he would be the first to admit that with a jumbled-up scheme of that nature there was no real financial incentive; all that one had done was to say "I cannot employ people at (so much) an hour because they will not work for me, and so I will figure out some bonus scheme which will give them (so much) more and bring their money up to (so much) and then they will work." Probably one would be better advised, instead of applying a time study, to get a man with plating experience to look into the movements made within the plating department, and then by a re-arrangement of the racks or by an alteration of technique one could afford to pay the operators a higher wage than they now obtained by their wage plus bonus, and to employ them for fewer labour hours and get higher efficiency.

MR. HARVEY, speaking as one who was himself engaged in time study work, said he had listened to the paper with great interest. He noticed that in the paper the author suggested that men chosen for the time study department should be men of great determination and character, and in answering questions he had suggested that they should be able to discriminate in the piecework incentives which they offered to operators and that they should be patient and tactful. He had also suggested that time and motion study should be applied to various departments in the build-up of the indirect labour to the direct. Personally, he thought that too

much was sometimes expected of the time study man, because, after all, the general run of managements to-day were quite satisfied as long as he made fairly good contracts in the shop ; but if there was a little trouble or the contact was a little too generous the time stu dy man suffered from one side or the other. It was too much to expect that the time study man should have great determination, a good knowledge of psychology, the patience of Job, and the wisdom of Solomon.

Mr. Dyson emphasised the fact that time study and motion study need not necessarily be carried out by a time study department or a motion study department. I was not essential to set up a department to do the work. It might be advisable to do so, just as it might be advisable to set up an inspection department ; but some factories did not do that, but relied on the superintendents, though still using inspection standards. Whether there was a special time and motion study department depended on how the method was to be applied. If it was to be applied in detail it was better to have a specific department to do it. He felt that this paper covered a very wide field, and therefore there were two things which he did not discuss : the technique of taking the studies and the method of building up the study department. Dozens of books had been written on these subjects, some good, some bad and some indifferent.

He did not think that any superhuman qualities were required by the time study engineer. He must know his job and know what he was looking for and how to record it. As with everything else, it needed special training to become a specialist in the subject. It might be said that a tool designer required very special qualities but many good tools had been produced by a foreman in the shop who was not a trained tool designer. On the other hand, if going in for tool-making in a big way one would have a tool design section in which a man would be employed who was a specialist in designing tools, and who would have much better qualifications that the foreman or operator who designed a good specific tool. So long as the time study man knew the job and knew what he was looking for he did not need all the qualifications which were often so nicely listed one after the other, or a good many men now holding the job would not hold it, and the salary which the others would demand would be far higher than that of the general manager.

Mr. Blackshaw, in proposing a vote of thanks to the author, said the remarks he had made earlier had been made primarily in the hope of provoking discussion, although there had been an element of sincerity behind them. He was sure, however, that everyone had greatly appreciated the paper, which must have involved an immense amount of hard work in its preparation.

The vote of thanks was carried with acclamation, and the meeting then terminated.

Research Department: Production Engineering Abstracts

(*Prepared by the Research Department.*)

NOTE.—*The Addresses of the publications referred to in these Abstracts may be obtained on application to the Research Department, Loughborough College, Loughborough. Readers applying for information regarding any abstract should give full particulars printed at the head of that abstract including the name and date of the periodical.*

HEAT TREATMENT.

Principles of Heat-Treating Steel, by H. L. Walker. (*Metallurgia, September, 1944, Vol. 30, pp. 282-283.*).

Extract from University of Illinois Bulletin, 6th June, 1944, Vol 41, No. 24, giving an improved iron-carbon equilibrium diagram.

(*Communicated by "Industrial Diamond Review."*)

Skin Recovery for Decarburised Steel Surfaces, by Orville E. Cullen. (*Machine Shop Magazine, January, 1945, Vol. 6, No. 1, 4 pp., 3 figs.*).

Reproduced from *Metals & Alloys* this article deals with the restoration of carbon in the surface of decarburised steel. The process involves heat treatment in a controlled atmosphere. Graphs show the difference between this process and normal carburising, the former giving a balanced carbon concentration from surface to core metal.

Sub-zero Treatment of Steel. (*Machinery, 11th January, 1945, Vol 66, No. 1683, 6 pp., 8 figs.*).

This article constitutes a thorough review of the principles of this treatment and its application to different types of steel.

Induction Heating. (*Sheet Metal Industries, January, 1945, Vol. 21, No. 213, 5 pp., 7 figs.*).

Part V. The use of induction hardening for the heat-treatment of gears is described. Particular attention is paid to the elimination of distortion and the accurate specification of steel necessary to obtain economy in alloying elements, machining costs, etc.

Practical Aspects of Induction Heating, by W. M. Roberds. (*Iron Age, 24th August, 1944, Vol. 154, No. 8, 5 pp.*).

Deals with relation of frequency and power to depth (in steel) of hardened layers and self-quenching; table of depths of penetration for Al, Cu, brass, hot and cold steel for various frequencies. Design of applicator coils is discussed in connection with control of current densities. References to brazing and soldiering.

(*Communicated by the British Non-Ferrous Metals Research Association*).

BELTS AND CHAINS.

Belting Incidentals, by H. S. Jude. (*Power Transmission, January, 1945, Vol. 13, No. 156, 5 pp., 4 figs.*).

A review of some of the more common pieces of subsidiary equipment which are used in workshop practice to prolong the life of transmission belts in service. These include : leather edges for fabric belts ; copper stitching and leather laces to secure two members into one belting unit ; belt dressing and degreasing.

Chain Drives in Industry. (*Power Transmission, 15th January, 1945, Vol. 13, No. 156, 4 pp., 3 figs.*).

The advantages claimed for chain drive are : Positive driving, high efficiency, smooth and silent running, reliability, longer life, and low maintenance cost. The action and construction of the inverted tooth type silent chain are described, and the importance of pinion size is indicated. The factors distinguishing normal from special operating conditions are set down. Generally it is not the power transmitted, but the type of load, that determines normal or special selection.

FURNACES.

Magnetic Devices Control Speed of Roller-Hearth Furnaces, by G. W. Heumann. (*The Machinist, 27th, January, 1945, Vol. 88, No. 42, 4 pp., 6 figs.*).

Automatic sequence controls and interlocking devices govern the passage of work trays through a heat-treating machine. Several ways of installing motor control are available, depending on the size of the furnace and space.

COOLANT AND LUBRICANT.

High Pressure and Continuous Lubrication, by W. J. Roberts. (*Power Transmission, January, 1945, Vol. 13. No. 156, 3 pp., 3 figs*).

A review of modern lubrication methods as applied to power transmission equipment, driving gears of individual machines and multi-point greasing from central control stations.

EMPLOYEES AND APPRENTICES.

Education and Training in the Sheet Metal Industry, by A. P. M. Fleming, C.B.E., D.Eng. (*Sheet Metal Industries, January, 1945, Vol. 21, No. 213, 8 pp., 3 figs.*).

The importance of a high standard of British craftsmanship is stressed. Education for craftsmanship should rest on a broad basis of general education. The " Junior Technical School " is most successful in preparing entrants to industry. Introduction of a State Apprenticeship Certificate, and the national recognition of craft courses is long overdue. A syllabus for such a course for the sheet metal trade is outlined. The advantage of part-time day release from industry is stressed, and its effect on industrial production discussed. Defects in the present methods of works' training are pointed out, and improvements suggested. The widespread introduction of special workshop schools is highly recommended. Importance is attached to the encouragement and provision of facilities for adult education.

FOUNDRY.

Aluminium Castings Made in Permanent Moulds, by John Vickers. (*The Machinist, 20th, 27th January, 1945, Vol. 88, Nos. 41, 42, 5 pp., 10 figs.*).

Nearly 80% of the castings for Merlin and other Rolls-Royce engines are made by this method. Savings in material and production time result. Castings are smooth, accurate and have high phsyical properties.

Gravity Die-Casting Technique, by G. W. Lowe. (*Book, 1944, 94 pp. Published by Hutchinson's Scientific and Technical Publications, London. 9s. 6d. B.N.F. Serial 27,506*).

The ten chapters deal with original casting developments, pressure die-casting and slush-casting, gravity die-casting, gravity die design (2 chapters), die-mould design (3 chapters), preparing the mould for the foundry. A smaller publication by the same author, [" Gravity Die-Casting Practice," 1943, 65 pp. (B.N.F. Serial 26,368) was noted in B.N.F. Bulletin 172, October, 1943, p. 305.]

(*Communicated by the British Non-Ferrous Metals Research Association*).

GEARING.

Influence of Tooth Design on Pitting of Gear Teeth, Parts I and II, by H. Walker. (*The Engineer, 22nd, 29th December, 1944, Vol. CLXXVIII, Nos. 4641, 4642, 6 pp., 13 figs.*).

Surface failure may occur in a variety of ways, the most important of which is pitting, since the others can usually be avoided by taking precautions which are not now difficult or unpractical. The author develops theories to show : (1) The load cycle of a gear tooth with correctly modified profiles starts at zero and increases proportionately to the distance of the point of contact from the starting point measured along the line of action until it reaches a maximum at the point where single contact starts. The full transmitted tooth load is maintained during the period of single contact, and then reduces to zero in proportion to the distance from the terminal point on the line of action. (2) Pitting takes place on the dedendum arc, starting at the point of maximum stress. This is usually in the region of single contact. (3) The stress is proportional to the square root of the load and inversely proportional to the square root of the relative radius of curvature. (4) Pitting has no direct relation to the pitch line, except that the pitch line happens quite fortuitously to be situated, in normal gear designs, at the location where pitting does usually take place, i.e., in the region of single contact or maximum stress. Gears have been made taking these theories into account, and tests have been carried out which confirm the improvement in load capacity and life of the specially designed gears ; standard and special gears were run in the same power circuit and in the same gear-box with a common lubricant, thus ensuring identical running conditions. The theories outlined were all confirmed by the experiments. To embody the results in the design of gears, the requirement to be borne in mind is that the theoretical tooth load at the pitch line, based on the straight line load cycle, should be less than, and if possible only 60% of, the full transmitted load. This calls for an exceptionally long pinion addendum and a short dedendum, coupled with a high pressure angle, usually 26 deg. to 30 deg. The limit to the amount of improvement which can be obtained will usually be found to be the land width at the tips of the pinion teeth. A simple design procedure, which enables standard gear-cutting tools to be used, is to cut the wheel as a standard 20°deg. pressure angle full-depth gear, and then to increase the running pressure angle and to alter the addendum proportions by increasing the diameter of the pinion above standard to such an extent that the desired results are achieved.

MACHINE ELEMENTS.

Setting Tolerances Scientifically, by William B. Rice. [*Mechanical Engineering, (U.S.A.), December, 1944, Vol. 66, No. 12, 3 pp., 1 fig.*].

For new products or old ones the scientific approach to the question is : (1) to find out what specifications are required in actual use ; (2) to determine how the required tolerances can be met most economically in factory production. A case history, taken from actual experience, illustrates how such a problem was tackled by an application of quality-control technique.

Drawing Office Practice Relative to Interchangeable Components, by C. A. Gladman. (*Machine Shop Magazine, January, 1945, Vol. 6, No. 1, 6 pp., 6 figs.*).

Part I. This paper, read before the Institution of Mechanical Engineers, describes the work of a special committee set up by the Admiralty to standardise drawing office practice in some of their own design departments. Basic principles are established for the guidance of designers when preparing drawings for interchangeable components, and logical methods of approaching solutions to dimensional problems and of stating them on drawings are discussed. This part deals with interchangeability requirements ; the use of basic dimensions and the assignment of tolerances ; functioning, manufacturing and inspection datums ; distance between two points or two surfaces ; limits, fits and gauge tolerances ; and positional work.

The Dimensioning of Production Drawings, by W. Barnes. (*Machinery, 25th January, 1945, Vol. 66, No. 1685, 4 pp., 5 figs.*).

Good general practice. Machining and surface-finish symbols. Limits and tolerances. Possible consequences when tolerances are not specified. Methods of dimensioning.

LIGHTING.

Electric Discharge Lamps and their Application to Industry, by M. W. Hime. (*Transactions of the Institution of Engineers and Shipbuilders in Scotland, January, 1945, Vol. 88, Part 3, 22 pp., 10 figs.*).

The development and principles of electric discharge lamps are described in considerable detail. The advantages of these lamps are ; instantaneous starting, high luminous efficiency, low brightness, spectral qualities closely akin to noon sunlight, small stroboscopic effect, and long life. Fluorescent tubes were first used to solve local lighting problems, but they are equally applicable to high mounting general lighting installations, and due to their special characteristics they enable high levels of illumination to be obtained without harshness. Applications are described for both general purposes and special cases.

MACHINING, MACHINE TOOLS.

Machining Magnesium. (*Machine Shop Magazine, January, 1945, Vol. 6, No. 1, 6 pp., 7 figs.*).

Tool angles, cutting speeds, rates of feed and depths of cut for turning and boring, shaping and planing, milling, and drilling are given.

The Technology of Diamond Machined Surfaces, by D. G. Beletsky, (*Industrial Diamond Review, December, 1944, Vol. 4, No. 49, 9 pp., 4 figs.*).

The fundamental conditions for precision machining are : high cutting speed, small feeds, and small depths. This article is mainly concerned with Russian

practice, and gives data on various operations with diamond and hard metal tools. Tables of service data and tool angles and radii for fine boring and turning are also given. Precision machining is compared with other finishing operations, and the following conclusions drawn : (1) Precision turning is much superior to reaming, broaching and partly to grinding for accuracy and smoothness of surface, particularly for non-ferrous metals and thin-walled components. (2) The output with single spindles is equal to that of grinding with longitudinal feed and when multiple spindle machines are used it may compete with the broaching process. (3) Precision turning represents the best method for preparing unhardened components for fine grinding operations (honing, superfinishing), processes which require high macro-geometrical accuracy of the preliminary machining operation. An analysis of foreign and Russian practice of precision machining classes the components for which this kind of machining is desirable. The technology of precision machining depends to a great estent on the equipment available. General principles are discussed and the Russian practice is reviewed. In the U.S.S.R. the introduction of diamond turning and boring caused equipment difficulties, as only a few factories producing machine tools for this purpose exist. Generally it is necessary in the U.S.S.R. to make use of the machine tools in general use such as lathes, boring machines and internal grinding machines. Experience shows that the accuracy of lathes available for producing medium quality components does not guarantee a satisfactory operation with tools of fixed adjustment. Hence attachments such as dogs with indicators and finely-ruled scales become necessary for providing quick and rapid adjustment of the tool edge. Some editorial comments are given.

Machining Steels on Automatics with Carbide Tools, by C. W. Blade. (*Canadian Machinery, August, 1944, Vol. 55, No. 8, pp. 80, 81, 137*).

Experience with carbide tipped tools for automatic screw machine operations ; cutting speeds higher than with H.S.S. tools ; too fine a feed for rough turning increases tool wear ; form tools require finer feeds from 0.0025 to 0.010 in./rev., and a harder grade carbide is generally used ; cutting-off tools offer special problems as they may start at proper cutting speed, but lose cutting speed approaching the centre in some cases, therefore, a cut is started by a carbide tool and completed by a H.S.S. tool ; rake angle in direction of feed 10 to 15 deg. ; tool grinding, proper lubrication and prevention of chatter mentioned.

(*Communicated by Industrial Diamond Review*).

Fixed Set-ups Employ Portable Tools. (*The Machinist, 13th January, 1945, Vol. 88, No. 40, 3 pp., 6 figs.*).

Electric drills can often be mounted in fixtures or on bench stands to decrease production time on repetitive jobs where work schedules do not warrant use of automatic equipment.

Dressing Grinding Wheels, by W. Fay Aller. [*Mechanical Engineering (U.S.A.). December, 1944, Vol. 66, No. 12. 4 pp., 10 figs.*].

The accepted method of dressing has been accomplished by the use of sharp diamonds, or other hard material such as the carbides, but crush-dressing has many advantages including : (1) On the most varied of profiles, crush-dressing forms the wheel to the desired shape in a fraction of the time possible by any of the previous conventional dressing methods. (2) Crush-dressing provides a better cutting surface with many more sharp cutting points and without the dull flats produced by diamond-dressing. (3) The number of pieces that may be ground per dressing is remarkably increased.

(4) The cost of dressing tools is greatly reduced, not only because of the number of pieces ground per dressing, but also because of the tremendous number of dressings possible with the crusher-dressed tools. Although still having some limitations, this is the modern inexpensive way of dressing a grinding wheel and getting the most intricate of shapes. (5) Longer wheel life is obtained by crusher-forming because it is only necessary to remove the dulled grits. The dressing operation itself does not tend to dull the grits as in diamond-dressing. (6) Crusher-dressing allows closer grinding of work, reduces hazard of burning, and less pressure is necessary to remove stock. These advantages are carefully reviewed. Examples of faster production with plunge-grinding are given.

Crushing Wheels for Form-grinding without Special Equipment, by W. Zikel. (*Machinery, 18th January, 1945, Vol. 66, No. 1684, 2pp., 3 figs.*).

A simple method of crushing the grinding wheel for form-grinding large batches of precision form tools of high-speed steel requiring accurate radii, angles and length of form. In this arrangement only a formed crusher provided with a special driving flange is required.

Automatic Milling of Side Teeth on Side and Face Cutters, by W. Zikel. (*Machinery, 11th January, 1945, Vol. 66, No. 1683, 4 pp., 5 figs.*).

An electro-pneumatic fixture used to increase output and quality.

Standard Milling Fixtures Increase Production, by C. H. Dixon. (*The Machinist, 6th January, 1945, Vol. 88, No. 39, 3 pp., 6 figs.*).

Set-up time has been reduced to a minimum through the use of fixtures for pistol bodies. One operator performs consecutive operations on several milling machines.

High Velocities Raise Band Saw Efficiency, by H. J. Chamberland. (*Machine Shop Magazine, January, 1945, Vol. 6, No. 1, 3 pp.*).

Reproduced from "*Canadian Machinery*" this article indicates that cutting speeds beyond 10,000 ft. per minute are possible when saw bands having a special tooth construction are employed. A large variety of steels are cut at 3,000 to 10,000 ft. per minute.

CHIPLESS MACHINING.

Metal Spinning Practice and Procedure. (*Sheet Metal Industries, January, 1945, Vol. 21, No. 213, 7 pp., 13 figs.*).

In certain cases the spinning process has decided advantages as a means of production, owing to low cost, for parts of circular cross-section symetrically disposed about the longitudinal axis of rotation. Values for the "spinnability" of a wide range of metals are given in these groups: aluminium, copper, common steels, stainless steels, nickel, and miscellaneous. The design and use of spinning lathes and tools are described, and the article concludes with notes on annealing and lubrication.

MANUFACTURING METHODS.

Motion Study is the Missing Function, by S. B. Dipple and B. R. Stephens. (*Machine Shop Magazine, January, 1945, Vol. 6, No. 1, 4 pp.*).

Part 1. Motion study has been largely ignored in this country due to prejudice and tradition. It has been opposed by: management; the product designer; the process planning engineer, the tool designer, and the time study

engineer; supervisors; the inspector; and the operator. Their reasons for doing so are discussed in some detail, but it is concluded that prejudice is the greatest obstacle.

Machining Aircraft Engine Propellor Shafts. (*Machinery, 4th January, 1945, Vol. 66, No. 1682, 6 pp., 10 figs.*).

Methods used in the production of the " Bristol " Hercules Engine.

MATERIALS.

Laminating Lumber for Extreme Service Conditions, by C. D. Dosker and A. C. Knauss. [*Mechanical Engineering* (*U.S.A.*), *December, 1944, Vol. 66, No. 12, 11 pp., 20 figs.*].

The seasoning of heavy timber is a time-consuming process, and laminating often provides a satisfactory answer to this problem, since standard thicknesses of dry lumber can be built up into structural members. Laminated lumber offers a number of advantages. Well-made laminated timbers are free from seasoning checks and shrinkage stresses and can be formed in curved or flat members in a wide range of cross-sectional sizes and lengths. Lumber of various species may be combined in them, with each utilised for its particular mechanical properties. The development of suitable weather-resisting glues provides joints that can serve in outdoor exposure without protection from rain and sunshine and withstand prolonged immersion in either salt or fresh water. The development work, laminating equipment, selection and preparation of lumber, preparation of glue, and curing are described, with particular reference to boat and shipbuilding. Some typical laminated products that have been made for use under severe exposure conditions include a 1-piece white-oak stem and keel for a 50-foot motor launch, and a set of 14-foot Southern yellow-pine railroad bridge stringers.

MEASURING METHODS.

Quality Control, by H. Howell. (*Aircraft Production, January, 1945, Vol. VII, No. 75, 4 pp., 6 figs.*).

Part 1. The article demonstrates the application of quality control principles to the instruction of operators and setters in a training school. The technique in brief consists of operating the machines with dial gauges instead of cutting tools. A special chart is provided on which are recorded the results obtained by the instructor and the trainee. The routine makes the trainee " process conscious " and aware of the possible sources of error. The routine for capstan lathes is detailed and analysed.

Quality Control: Application to the Inspection of Light Alloy Castings, by F. A. Allen. (*Met. Ind., 24th November, 1944, Vol. 65, No. 21, 3 pp.*).

Paper to Bristol Branch of the Institute of British Foundrymen. By statistical control the need for a 100% inspection test can be avoided. Suggests basing radiography of castings on statistical control.

(*Communicated by the British Non-Ferrous Metals Research Association*).

RADIOGRAPHY.

X-rays and Industrial Diamonds, by E. J. Tunnicliffe. (*Industrial Diamond Review, December, 1944, Vol. 4, No. 49, 3 pp., 8 figs.*).

Part II. Investigations were carried out on tools tipped with shaped diamonds. Eight illustrative examples are given together with brief notes on the conditions disclosed.

RESEARCH.

Strain Gauging for Machine Tools, by Paul I. Smith. (*Machinery, 4th January, 1945, Vol. 66, No. 1682, 1 p.*).

The author proposes utilising the strain gauges developed for aircraft work to find the distribution and extent of stresses imposed on cyclically-stressed parts on machine tools under operating conditions.

Basic Mechanics of the Metal Cutting Process, by E. Merchant. (*J. Applied Mechanics, September, 1944, Vol. 11, No. 3, 8 pp.*).

Mathematical analysis of the geometry and mechanics of the metal-cutting process. Analysis offers key to study of engineering problems in the field of cutting in terms of strain, rate of shear, friction between chip and tool, shear strength of the metal, work done in shearing the metal and in overcoming friction. Theoretical findings said to be particularly applicable in high-speed machining with sintered-carbide tools.

(*Communicated by the British Non-Ferrous Metals Research Association*).

An Investigation of Radial Rake Angles in Face Milling, by J. B. Armitage and A.O. Schmidt. [*A.S.M.E. Transactions (U.S.A.), November, 1944, Vol. 66, No. 8, 11 pp., 18 figs.*].

This paper (by the Vice-President and the Research Engineer of the Kearney & Trecker Corporation) forms one of the most thorough reports yet published. The object of the investigation was to determine the effect of negative and positive radial rake angles in milling cutters upon the power required for the cutting action, the tool life of the cutter, the surface finish, and temperature of the workpiece. Tests were conducted with 2-inch face mills which had two brazed carbide tips. All cutters had the same dimensions except for the radial rake angles which included 30 deg., 15 deg., 6 deg., positive ; 0 deg., 6 deg., 12 deg., 20 deg., and 30 deg., negative. The axial rake angle was 0 deg., on all of the cutters. Cutting speeds were varied in seven steps between 106 and 785 fpm ; different feeds were used with each speed and the depth of cut was constant at 0.125 in. Test bars were made of normalized S.A.E. 1055 hot-rolled stock. This steel was used throughout the investigation except for the tool-life tests in which S.A.E. 1020 was also used. Equipment and procedure used in the tests are discussed and the results illustrated by several graphs. Clearly defined conclusions are drawn from the investigation.

Machinability of Plain-Carbon, Alloy, and Austenitic (Nonmagnetic) Steels, and Its Relation to Yield-Stress Ratios When Tensile Strengths are Similar, by E. J. Janitzky. [*A.S.M.E. Transactions (U.S.A.), November, 1944, Vol. 66, No. 8, 4 pp., 3 figs.*].

It is possible by the use of yield-stress ratios of plain-carbon, alloy, and austenitic (nonmagnetic) steels of the same tensile strength to obtain an index of machinability for rough-turning. The relation between Taylor speed and yield stress ratios of the same tensile strength is expressed mathematically in the paper. A graphical presentation is also given. The yield-stress ratios of steels of the same tensile strength allow co-ordination of machinability of the types of steel listed by the same method, a distinct advantage over the use of any one of the four components of the tensile test alone, or a combination of stress and strain.

Effect of Grain Size and Sub-zero Treatment on Productivity of Four High-Speed Steels, by S. M. Depoy. (*A.S.M.E. Transactions, (U.S.A.), November, 1944, Vol. 66, No. 8, 4 pp., 5 figs.*).

The effect of grain size and sub-zero treatment on the productivity of four high-speed steels was studied by means of a series of turning tests on one alloy

steel under uniform conditions. Standard and sub-zero treatments were used at different hardening temperatures to develop different grain sizes and different hardening products. The results obtained show that the grain size, carbide solution, and type of martensite formed in the tool have a very marked effect on its cutting ability. It appears that sub-zero treatment is much more effective when large grain sizes are developed.

SHOP MANAGEMENT.

Batch Production Control., by D. Tiranti. (*Machine Shop Magazine, January, 1945, Vol. 6, No. 1, 9 pp., 4 figs.*).

Large orders must be split into small batches that can be handled conveniently on the plant available. The purpose of this article is to present an analysis of a method of controlling batch production and the approach that has been taken to the subject is on the following basis : (1) General observations ; (2) initiation of batching ; (3) batch size ; (4) batching instructions ; (5) batch control ; (6) batch load schedule ; (7) progress chart ; (8) quantity made as against quantity ordered ; (9) replacement batch ; (10) recording ; (11) batch control sheet ; (12) use of correct store ; (13) assembly ; (14) split batching ; (15) conclusion.

Material Control, by W. Metcalfe. (*Machinery Lloyd, 20th January, 1945 Vol. XVII, No. 2, 6 pp., 2 figs.*).

After the scope of material control is defined, the introduction of a system is traced from the appointment of personnel through the examination of the existing system, the preparation of a flow chart for documents and materials, to the planning and establishment of the new system.,

SMALL TOOLS.

Cutting Tools, by L. Sanderson. (*Machinery-Lloyd, 6th January, 1945, Vol. XVII, No. 1, 6 pp., 8 figs.*).

The comprehensive research into the cutting capabilities of lathe tools, carried out by the Lathe Tools Research Committee of the Manchester Association of Engineers is summarised briefly, and performance tables are quoted. The modern tendency is to consider cutting tools in regard to the following fundamental points : (a) The form of chip production ; (b) the prevention of vibration at the tool nose ; (c) the kind of finished machined surface desired ; (d) The degree of tool wear ; (e) the relation of cutting speed to tool life ; (f) the material to be cut ; (g) speeds and feeds ; (h) the type of high speed steel used for the tool, or the type of tool (e.g., whether brazed, butt-welded, deposit-welded, etc.) : (i) the coolant. The practical aspects of these fundamentals are discussed. Attention is drawn to the present lack of standardised tool nomenclature.

Industrial Diamonds, by P. Grodzinski. (*Aircraft Production, January, 1945, Vol. VII, No. 75, 4 pp., 9 figs.*).

This forms a general descriptive article covering : types of stones and their choice ; diamond structure ; correct orientation ; the orientation of special tools ; truing tools and diamond powder.

Milling Cutters. (*Aircraft Production, January, 1945, Vol. VII, No. 75, 1 p., 2 figs.*).

Considerable time and cost-saving is claimed for a new staggered-tooth type which comprises eight sintered-carbide tools mounted in an adaptor.

Built-up Dies. (*Machine Shop Magazine, January, 1945, Vol. 6, No. 1, 3 pp., 3 figs.*).

Trouble was experienced with cracking in a die. It was overcome by using a built-up die.

STANDARDISATION.

Commercial Standard for Dial Indicators. (*The Machinist Reference Book Sheet, 20th January, 1945, Vol. 88, No. 41, 2 pp., 4 figs.*).

Nomenclature, dimensions, accuracy required, etc., taking effect in U.S. from 1st January, 1945.

SURFACE, SURFACE TREATMENT.

Simple Interferometer for Surface-Quality Measurement, by L. Leinert. (*Werkstattstechnik Der Betrieb, 1943, Vol. 37, pp. 279—289, abstracted in Engineers' Digest, 1944, Vol. 5, pp. 247—248*).

The interference method can be used for measuring surface irregularities of less than 0.5 microns, but if sodium light is used surface irregularities as small as 0.05—0.6 microns can be detected. An adaptation to a microscope (150 ×) is described, in which a glass screen plated with silver is used, whereby the silver film touches the surface to be examined. Outlines of working principle and illustration of apparatus and tested surfaces (precision ground, honed and lapped) given.

(*Communicated by Industrial Diamond Review*).

Surface Finish—What Surface Profile is Really Like, by L. H. Milligan. (*Grits and Grinds, October, December, 1944, Vol. 34, pp. 3—10, pp. 7—13*).

Introduction, Surface Finish definitions, American Standards and other Standards. Abbott's profilometer and Brush surface analyser ; roughness versus duplex surfaces ; waviness and "lay" of surfaces ; accuracy and dimensional trueness of surface photographs, profile sections, taper sections, electron microscope photographs (Magnification 9,000), levigated alumina, surface finish by hand stroking, metallographic polishing, fine grinding, abrasive lapping.

(*Communicated by Industrial Diamond Review*).

The Pickling of Steels, Part III, by E. W. Mulcahy. (*Sheet Metal Industries, January, 1945, Vol. 21, No. 213, 4 pp., 4 figs.*).

This part deals with acid fume extraction. The only effective way to extract acid fumes so as to neutralise their potential damaging effect is to collect them at the tank top. Suitable fans, extraction hoods and gas scrubbers are described.

WELDING.

Joining Aluminium Alloys, by E. C. Hartmann, G. O. Hoglund, and M. A. Miller. (*Steel, August 7—September 11, 1944, Reprint, 23pp., B.N.F. Serial 27,813*).

Authors (of Alcoa) give six fairly detailed reports on accepted (U.S.A.) practices for fabricating Al alloys by riveting, welding (gas, metallic arc, carbon arc, atomic hydrogen and resistance processes), brazing (furnace, torch and dip methods). Soldering and resin bonding.

(*Communicated by the British Non-Ferrous Metals Research Association*).

Arc Welded Cutting Alloys, by E. C. Rollason and P. Harris. (*Metallurgia, Vol. 31, No. 181,*).

Alloys of high hardness have many applications when deposited on tougher materials; they are applied where high hardness, high polish and low co-efficient of friction and high abrasive resistance are required. In this article attention is especially directed to their application for cutting purposes and to their deposition by the arc welding method.

(*Communicated by "Welding."*)

Electrode Coatings, by G. Haim. (*Welding, January, 1945, Vol. XIII, No. 1, 5 pp., 8 figs.*).

An account of a method for the rapid determination of moisture content.

Argon-Arc Welding. (*Welding, January, 1945, Vol. XIII, No. 1, 4 pp., 4 figs.*).

This process has been developed to avoid the difficulties which are present when using oxy-acetylene welding on magnesium alloys. It is stated that it offers a satisfactory means of obtaining sound, consistent welds in magisium alloys from the consideration of both strength and metallurgical structure. An electrode holder carries the welding current to the tungsten electrode and at the same time allows argon to pass to the gas nozzle which surrounds the electrode. The flow of argon forms a protective shroud around the electrode and the work. A direct current welding set is used.

Oxy-Acetylene Welding, by F. Clark. (*Sheet Metal Industries, January, 1945, Vol. 21, No. 213, 6 pp., 10 figs.*).

Part 2. The techniques for leftward, rightward, and vertical welding, and the advantages of each method are described.

The Geometry of the Spot-Welding Tip and its Relation to Tip Life (Light Alloys), by E. D. Crawford and C. W. Steward. (*Welding, J. J. Amer. Welding Soc.), October, 1944, Vol. 23, No. 10, 5 pp.*).

Suggestions on how to prolong tip life in the spot welding of light alloys, by preshaping tips in the machine.

(*Communicated by the British Non-Ferrous Metals Research Association*).

The Study of Electrode Tip Wear in the Spot Welding of Mild Steel Sheet, by W. S. Simmie. (*Sheet Metal Industries, January, 1945, Vol. 21, No. 213, 6 pp., 7 figs.*).

Controlling the electrode tip size is essential to maintain consistent welding results. This investigation included the welding of 20, 16, and 10-gauge mild steel sheet. Carefully controlled tests were carried out, and it was concluded that: (1) tip wear depends upon the shape of the electrode tip, and a truncated cone having an angle of 30° at the base is recommended, (2) tip wear is reduced by using chromium copper, (3) increase in tip area is not related to the increase in actual contact area, (4) much greater latitude is permissible in the welding of mild steel than with alloy steel.

Power Factor Correction of Resistance Welders, by W. B. Best. (*Welding, January, 1945, Vol. XIII, No. 1, 4 pp., 3 figs.*).

Due to their high peak loads and low power and load factors, resistance welders cause serious supply difficulties which cannot be overcome by usual methods. The use of series-connected, instead of parallel-connected, condensers has, however, met with considerable success.

Design Considerations in Resistance Welding, by A. J. Hipperson. (*Welding, January, 1945, Vol. XIII, No. 1, 9 pp., 8 figs.*).

This article first reviews the use of symbols on drawings, and suggests a simplified form of the system put forward by the American Welding Society. It then deals with general design requirements for spot, projection, seam, and flash butt welding, including material, strength of welds, arrangement of welds, and dimensions required.

WORKS AND PLANT.

Three Dimensional Planning, by R. W. Mallick. (*Mechanical Engineering (U.S.A.), December, 1944, Vol. 66, No. 12, 5 pp., 9 figs.*).

Many hundreds of hours can be spent by planning engineers in devising a layout and every feature may be mentally visualized by them, but these impressions are often difficult to convey to managers and supervisors by the present practice of template layouts and engineering drawings. Many persons who are required to review and pass judgement on the merits of a layout they may be required to operate cannot easily visualise the plant that is represented by the two-dimensional layout. When three dimensions are employed many of the difficulties disappear. The layout can be prepared, fully utilizing the cubical space rather than the floor areas only as is often done at present. It is claimed that the layout can be prepared in much less time and at a much lower cost than by the conventional one-plane method, despite the fact that perspective sketches or three-dimensional models look expensive.

Filtration of Industrial Water, by J. V. Brittain. (*Mechanical World, 19th January, 1945, Vol. 117, No. 3029, 3 pp., 3 figs.*).

The aspects which have to be considered include : (1) matter in suspension ; (2) dissolved minerals likely to cause trouble ; (3) hardness of the water ; (4) acidity or alkalinity ; and (5) contamination. Their relative importance depends on the source of the water, and the use to which it will be put. The process of treating water can be divided into : (a) preliminary treatment including filtration ; (b) chemical treatment including softening ; (c) special treatment for steam raising ; and (d) sterilisation.

The Reclamation of Swarf. (*Machinery, 18th, 25th January, 1945, Vol. 66, Nos. 1684, 1685, 10 pp., 10 figs.*).

By careful separation and selection, several thousand tons of aluminium scrap are made available to the aircraft industry yearly. One of the most comprehensive schemes now operating at an aero-engine factory is fully described and illustrated and a flow diagram is given showing the flow arrangements of the various materials and oils.

MISCELLANEOUS.

Infringement of Patent Rights. (*Mechanical World, 19th January, 1945, Vol. 117, No. 3029, 2 pp., 1 fig.*).

This article gives details of procedure illustrated by a hypothetical example.